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QUALITY CONTROL IN DOD

A School of Systems and Logistics Sampling Report

Air University

Air Force Institute of Technology

Wright-Patterson AFB, Ohio

By

George A. Bohlen
Lt Col, USAF

&

Patrick J. Sweeney
Lt Col, USAF

December 1976

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This book has been prepared for th imary purpose of serving as the textbook in the Graduate Logistics Program and more specifically the Quality Control course.

Virtually all of the texts in Quality Control are oriented to the manufacture of new products. The Air Force and the Department of Defense manufacture few products, but procure many products and are responsible for maintenance and repair of vast quantities of equipment. It is the authors' beliefs that many of the concepts and techniques of statistical quality control can be used to design and operate quality control systems in many areas of the Department of Defense and the Air Force to improve the effectiveness and efficiency of their operations.

Included in this text are statistical tolerancing, process control, the statistical background of sampling theory, the attribute and variable sampling plans, and the MIL-STD 105D and 414. Mastery of the included material is only a beginning but will basically qualify the student to establish quality sampling plans and to manage quality systems.

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FOREWORD

If the Air Force is to carry out its mission within ever tightening financial constraints, it must insist that the products and processes it requires meet prescribed levels of quality. Not only is this true of the characteristics of newly purchased items, but it is also applicable to maintenance and provisioning activities, work done to standards at base and unit levels, and office and staff functions as well. When an item or task must meet specified criteria to be acceptable, some form of quality control is appropriate.

Lt Col Bohlen and Lt Col Sweeney have combined their considerable experience and expertise in this volume to explain the principles of quality control in a logistics and facilities management context. Earlier versions of the work, appearing as class handouts, have been used in the Quality Control course offered in the Graduate Management Program in the School of Systems and Logistics, Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio. The course is offered as an elective in the fourth or fifth quarter of a concentrated one-year program. Typically a student has completed a two-course sequence in statistics, and at least one course in systems analysis prior to this subject. However, the mathematical topics are kept at an intermediate level, and the authors develop important concepts assuming only a modest background in probability and statistics. This broadens considerably

the usefulness of the text to busy managers facing the need to measure and control quality.

The authors are careful to place emphasis on the pragmatic aspects of quality control. They begin their study with an investigation of DOD and Air Force policy and working definitions underlying quality control. They refer often to appropriate MIL standards, including as appendices, MIL-STD-105D Sampling Procedures and Tables for Inspection by Variables for Percent Defective. Further, Lt Cols Bohlen and Sweeney have provided numerous examples illustrating how the various notions may be used in specific situations.

The technical material is divided into two major themes: (1) process control through the use (primarily) of control charts and (2) sampling methods by which basic data on an ongoing process is gathered and assessed. As each topic is developed, the reader can trace the context in which the technique is appropriate, the underlying rationale, and basic procedures for carrying out the control or measure. The authors refer to acknowledged authorities for detailed theoretical developments, freeing the practitioner to see the connection between the recommended schema and the problem at hand, while directing the student's attention to the theory necessary for understanding the foundations upon which the methods are based.

I am sure you will find this text by Lt Cols Bohlen and Sweeney useful in the classroom to gain a firm appreciation of quality

principles. It should also prove valuable as a practical
in the field to aid the manager in establishing and operating
lid and cost effective control system.

ARD J. FISHER, Ph.D.

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EDWARD J. FISHER, Ph.D.

PREFACE

This book has been prepared for the primary purpose of serving as the textbook in the Graduate Logistics Program and more specifically the Quality Control course.

Virtually all of the texts in Quality Control are oriented to the manufacture of new products. The Air Force and the Department of Defense manufacture few products, but procure many products and are responsible for maintenance and repair of vast quantities of equipment. It is the authors' beliefs that many of the concepts and techniques of statistical quality control can be used to design and operate quality control systems in many areas of the Department of Defense and the Air Force to improve the effectiveness and efficiency of their operations.

Included in this text are statistical tolerancing, process control, the statistical background of sampling theory, the attribute and variable sampling plans, and the MIL-STD 105D and 414. Mastery of the included material is only a beginning but will basically qualify the student to establish quality sampling plans and to manage quality systems.

The authors have gleaned material from many sources in this fascinating area. Of particular note is the outstanding work by the Army Management Engineering Training Agency. For the serious

student who wishes to pursue this topic in more detail, we recommend "Quality Control and Industrial Statistics" by A. J. Duncan.

We wish to thank Mrs. Carletta Clemmer, Mrs. Kay Atkins and Mrs. Renita Rapp for their editorial assistance. A special thanks to Betty Nelson who took our scribbled notes and turned them into a legible document.

CHAPTER I

INTRODUCTION

Department of Defense (DOD) Policy

The Department of Defense policy with regard to quality assurance is set forth in DOD Directive 4155.1, 9 Feb 1972, subject: Quality Assurance. The purpose of this directive is stated as follows:

> This directive establishes Department of Defense quality assurance policies designed to assure that all materiel, data, supplies and services developed, procured, stored, operated, maintained, overhauled, or disposed of by or for the Department of Defense meet the following objectives:
>
> A. that materiel, data, supplies and services conform to specified requirements.
>
> B. that specified requirements for materiel, data, supplies and services are practical and enforceable; and
>
> C. that user dissatisfaction and mission ineffectiveness are prevented or eliminated.

The directive expands on the above objectives and specifically states that the policies apply to supply, storage, and maintenance activities as well as procuring or producing activities.

Air Force Policy

Air Force policy with regard to quality assurance is set forth in Air Force Regulation 74-1, 4 Aug 1975, subject: Quality Assurance Program. This regulation expands on the DOD policy to emphasize the application to Air Force activities. This regulation specifically states that the policies apply to supply, storage, transportation and maintenance activities as well as procuring activities.

Both the DOD Directive and the Air Force Regulation require the establishment of appropriate control systems to maintain acceptable levels of quality.

Definitions

The following definitions are quoted from DOD sources:

A. Quality: The composite of materiel attributes including performance (DOD-D-4155.1, 9 Feb 1972; MIL-STD-109-B, 4 Apr 1969; AFR 74-1, 4 Aug 1975).

B. Quality Assurance: A planned and systematic pattern of all actions necessary to provide adequate confidence that the item or product conforms to established technical requirements (DOD-D-4155.1, 9 Feb 1972; MIL-STD-109-B, 4 Apr 1969; AFR 74-1, 4 Aug 1975).

C. Quality Control: A management function whereby control of quality of raw or produced material is exercised for the purpose of preventing production of defective material (MIL-STD-109-B, 4 Apr 1969, AFR 74-1, 4 Aug 1975).

There are a number of other definitions for the above terms set forth by various authors. Hayes (1974) defines quality control as ". . . a management function which must have the authority to regulate conditions that affect product quality." Hoffman (1971) defines quality control as ". . . the proper control of quality of a product to assure customer satisfaction."

The author of this handout includes in the definition of quality control all actions by management to control the quality of products and/or services including design, production, procurement, supply, transportation, storage, maintenance, and disposition. Quality control systems need not be limited to the production or procurement of materiel but can be effectively applied in other areas as well.

The following definitions will aid in discussing the quality of a product or service:

Quality Characteristic. Kirkpatrick (1970) defines a quality characteristic as a "property (e.g., a dimension, a temperature, a pressure, etc.) used to define the nature of a product." For example, the size dimensions, the degree of roundness or straightness, the surface character, the color, the strength, and the hardness all might be quality characteristics of a materiel item. The quality characteristic of a "service" type item might be the letters on a typewritten page, or the numbers/letters on a supply requisition. The quality characteristic of a maintenance type item might relate to the calibration of an instrument, the liquid level in tanks or gauges, the air pressure in tires, or the torque level required on certain bolts.

Quality of Design refers to a difference in specification for the same functional use (Kirkpatrick, 1970). For example, if two parts were designed to perform the same function and one had a specification of ten inches plus or minus one-half inch (10.000 ± 0.50) and the other had a specification of ten inches plus or minus one-quarter inch (10.000 ± 0.25), the part with the $\pm$ one-quarter inch specification would have the "better" quality of design--in other words, its specification would be "tighter." It should also be noted that, in general, as the quality of design gets better (tighter), the cost of providing the item or service increases.

Quality of Conformance refers to the degree to which the manufactured product conforms to the specification (Kirkpatrick, 1970). For example, if one part produced to either of the specifications

stated in the above paragraph measured "10.01" and another measured "10.02", the "10.01" part has a better quality of conformance.

Brief History of Statistical Quality Control

Prior to the advent of mass production of products, all parts were individually made and parts mated in the shop. Since each part was individually made and fitted, there was not a predetermined standard against which each part was compared. The quality was determined by the product's performance and its performance determined the maker's reputation.

In the early 1800's, Eli Terry began the mass production of clocks, and simple gauges were used to insure the interchangeability of parts. As industrial development continued and mass production increased, small scale inspection procedures were no longer adequate due to the large number of parts being mass produced.

It is generally agreed that the first person to apply statistical methods to quality control was Walter A. Shewhart of the Bell Telephone Laboratories in the 1920's. Production of telephone handsets was about 10 million annually. Western Electric Company and Bell Telephone Laboratories combined their efforts to produce a product which would withstand hard public usage with increased reliability. In 1924 Shewhart presented his initial thoughts on control of quality during manufacturing, later to be published in his book, Economic Control of Quality of Manufactured Product.

Two other Bell pioneers, H. F. Dodge and H. C. Romig, applied statistical theory to sampling inspection to produce their widely used Sampling Inspection Tables.

Until World War II, acceptance of the Bell methods was slow. The publication of Military Standard 105 forced suppliers to adopt equivalent inspection procedures to keep their products from being rejected by the military services. The environment had changed from one of fairly simple products to complex systems requiring new controls of men, materials, and machinery.

During the 1950's to the 1960's, systems became more complex and the emphasis was on quality products.

> Attention was focused on system integration, component compatability, producibility, value engineering and systems maintainability--all to be undertaken in the frame of reference of standard parts, mass production techniques, and extremely high standards of reliability (Hayes, 1974).

Statistical quality control techniques are widely used through-our industry today. The American Society for Quality Control, formed shortly after World War II, is one of the leading forces in promoting the uses of and advances in statistical quality control. Their publication, Quality Progress, is the successor to their earlier publication Industrial Quality Control.

CHAPTER II

STATISTICAL TOLERANCING

Introduction

MIL-STD-109B, 4 Apr 1969, defines the "specification" as:

> A document intended primarily for use in procurement, which clearly and accurately describes the essential and technical requirements for items, materials, or services, including the procedures by which it will be determined that the requirements have been met. Specifications for items and materials may also contain preservation, packaging, packing and marking requirements.

In general, the technical specification establishes the "quality of design" of an item or service. The degree to which an item or service conforms with the specification establishes the "quality of conformance."

The remainder of this chapter is concerned with establishing the technical specifications for parts or assemblies. The objective is to acquaint the student with some of the terminology of technical specifications and to demonstrate that the concept of statistical tolerancing can be used to greatly increase the tolerances on individual component parts without adversely affecting the quality of design of the overall "assembly."

Tolerancing

The "tolerance" of a part refers to the total variation permitted in producing (or maintaining) the part. There are basically two ways in which the tolerance can be specified. The first method states a "design size" to which tolerances are applied. The plus and minus tolerances for this design size do not have to

be equal. Specifications (a) through (d) below are all examples of this type of tolerancing; the design sizes being 10.00, 9.99, 10.01, etc. and the tolerances being ± .01; $^{+.02}_{-.00}$; $^{+.00}_{-.02}$; etc. The second method simply states the upper and lower limit of the specifications such as (e) below. Tolerances specified by the first method can always be changed to that of the second method. In other words, if the tolerances shown in (a) through (d) below refer to the dimension X_A in Figure 1 or X_B in Figure 2, they can all be reduced to a dimension with a minimum limit and a maximum limit such as in (e) below.

(a) $10.00 \pm .01$

(b) $9.99 \; ^{+\,.02}_{-\,.00}$

(c) $10.01 \; ^{+\,.00}_{-\,.02}$

(d) $10.005 \; ^{+\,.005}_{-\,.015}$

(e) 9.99 and 10.01

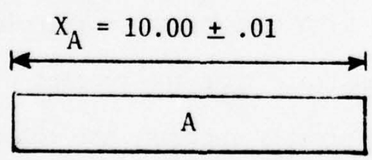


Figure 1

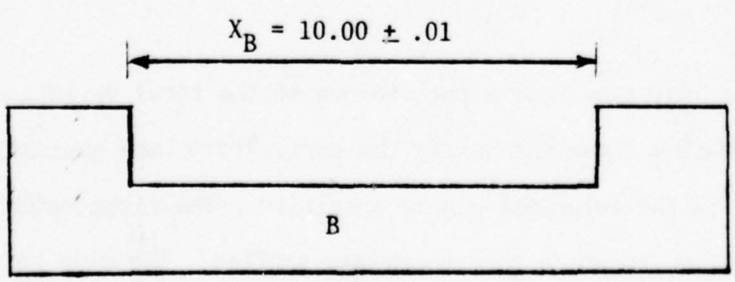


Figure 2

Nominal Size

The "nominal" size of a part is used for general identification only. For example, a part which is specified to be manufactured to a dimension of .995" to 1.005" might be said to have a nominal size of 1". The nominal size can also refer to the mean dimension of the two limits regardless of how these limits are specified. For example, the nominal size of dimensions X_A and X_B in Figures 1 and 2 is 10.00" regardless of which method of specifying the tolerance was used.

Clearance

The clearance refers to the difference between an interior dimension and the adjacent exterior dimension of two mating parts such as shown in Figure 3.

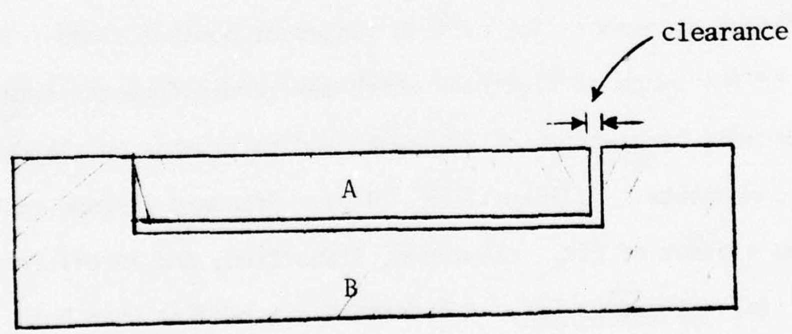


Figure 3

The maximum clearance is defined as the maximum interior dimension (e.g., X_B on Figure 2) minus the minimum exterior dimension (e.g., X_A on Figure 1) of the mating parts.

The minimum clearance is defined as the minimum interior dimension minus the maximum exterior dimension of the mating parts. These

clearances can be negative which indicates that there is a pressure fit. If a negative clearance is an acceptable condition, the parts are forced together by pressure, fitted by heating or cooling, or mated in some other manner.

Allowance

The allowance is the minimum specified clearance. This is the tightest fit allowed under the prescribed tolerances. This condition is achieved when the mating parts are manufactured to their maximum material limits, i.e., the maximum permissible material is left on the parts.

System of Fits

There are several systems for classifying types of fits based on specified allowances for certain ranges of nominal sizes. Fit refers to the range of tightness which may result from the application of a specific combination of allowance and tolerances in the design of mating components. (Kirkpatrick, 1970). Standard systems result in three classes of fit: clearance, transition, and interference.

(a) Clearance Fit. A clearance fit results when both the maximum and the minimum clearances are positive. For example, the following specifications for parts A and B (as shown in Figures 1 and 2 and assembled as shown in Figure 3) results in a clearance fit:

$$X_B = 10.500 \pm .002$$

$$X_A = 10.495 \pm .002$$

$$\text{Maximum Clearance} = 10.502 - 10.493 = + .009$$

$$\text{Minimum Clearance} = 10.498 - 10.497 = + .001$$

(b) Transition Fit. A transition fit results when the maximum clearance is positive and the minimum clearance is negative. For example, the following specifications result in a transition fit:

$X_B = 10.501 \pm .003$

$X_A = 10.497 \pm .002$

Maximum Clearance = 10.504 - 10.495 = +.009

Minimum Clearance = 10.498 - 10.499 = -.001

(c) Interference Fit. An interference fit results when the maximum and minimum clearances are both negative. For example, the following specifications result in an interference fit:

$X_B = 10.500 \pm .001$

$X_A = 10.503 \pm .001$

Maximum Clearance = 10.501 - 10.502 = -.001

Minimum Clearance = 10.499 - 10.504 = -.005

Within each class of fit are grades of fits which result from further limits on tolerance combinations.

Additive Tolerancing

Under the concept of additive tolerancing, it is assumed that 100% of the parts are produced within the design specifications and that there is full and complete interchangeability of parts. Under this concept, if parts A, B, C, and D shown in Figure 4 are produced to the tolerances indicated below, the total tolerance is calculated as follows:

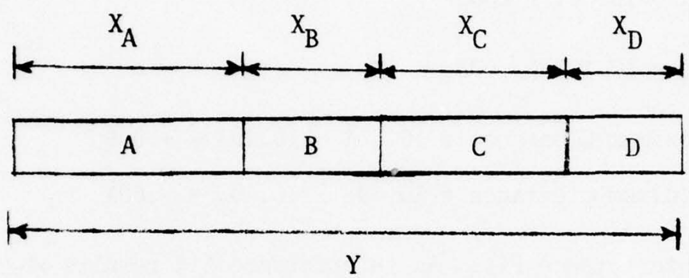


Figure 4

$X_A = 3.000 \pm .006$

$X_B = 2.000 \pm .006$

$X_C = 3.000 \pm .006$

$X_D = 2.000 \pm .006$

Determination of the design dimension, Y, from the design dimensions X_A, X_B, X_C, and X_D is as follows:

$$Y = X_A + X_B + X_C + X_D$$

$$Y = 3.000 + 2.000 + 3.000 + 2.000$$

$$Y = 10.000$$

Determination of the tolerances for Y is as follows. Note that tolerances always add!

Maximum Tolerance = + .006 + .006 + .006 + .006 = .024

Minimum Tolerance = + .006 + .006 + .006 + .006 = .024

Specification is 10.000 $\pm$ .024

If Y were specified to be 10.000 $\pm$ .016 and the <u>individual part tolerances were specified to be allocated equally</u>, then the tolerance for each component part would be $\pm$ .016/4 = $\pm$ .004.

The additive tolerance for Y on an assembly such as that shown in Figure 5 is computed as follows:

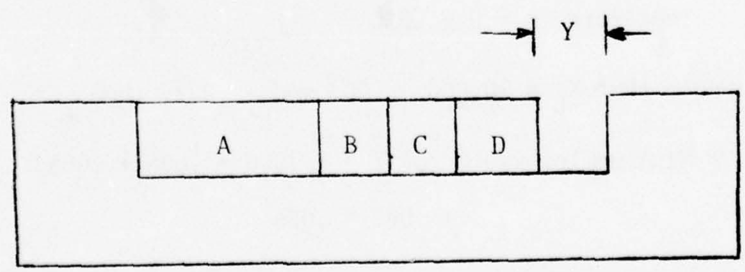


Figure 5

$X_A = 3 \pm .006$

$X_B = 2 \pm .006$

$X_C = 3 \pm .006$

$X_D = 2 \pm .006$

$X_E = 10 \pm .006$

$Y = 10 - (3 + 2 + 3 + 2) = 0$

To compute the maximum tolerance, we find the tolerances for the <u>minimum</u> <u>material</u> <u>limit</u> on each part and <u>add</u> these tolerances.

Maximum Tolerance for $Y = .006 + .006 + .006 + .006 + .006 = .030$

To compute the minimum tolerance, we find the tolerances for the <u>maximum</u> <u>material</u> <u>limit</u> on each part and <u>add</u> these tolerances

Minimum Tolerance for $Y = .006 + .006 + .006 + .006 = .030$

Therefore, $Y = 0 \pm .030$

Suppose that $X_E = 10.000 + .003$ and $- .002$, then

Minimum Tolerance for $Y = + .006 + .006 + .006 + .006 + .002 = .026$

Maximum Tolerance for $Y = .006 + .006 + .006 + .006 + .003 = .027$

Therefore, $Y = 0 + .027$ and $- .026$

In working problems like that above, one must keep in mind that the minimum tolerance is based on the maximum material limits and the maximum tolerance is based on the minimum material limits.

Example Problem

You have been advised that the following tolerances have been established for parts A, B, C, D, and E in Figure 6:

$X_A = 2.000 \pm .003$

$X_B = 1.000 \pm .003$

$X_C = 1.000 \pm .003$

$X_D = 3.000 \pm .003$

$X_E = 7.009 \pm .003$

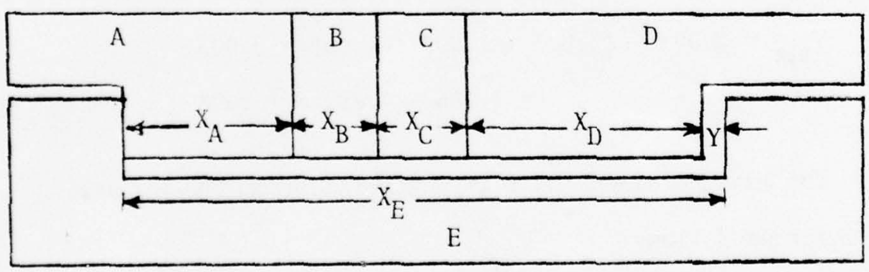


Figure 6

Using additive tolerancing assuming full interchangeability, answer the following:

(a) Determine the minimum, maximum, and average dimension "Y".

(b) What class of fit is this? Why?

<u>Solution</u>

a. (1) Y design dimension

$$Y = 7.009 - (2.000 + 1.000 + 1.000 + 3.000) = .009$$

(2) Minimum Tolerance = .003 + .003 + .003 + .003 + .003 = .015

(3) Maximum Tolerance = .003 + .003 + .003 + .003 + .003 = .015

Specification is .009 ± .015, therefore, minimum Y dimension is -.006, the maximum Y dimension is + .024, and the average dimension is + .009.

Another method of solution is to find the minimum dimension Y by finding the maximum material limits as follows:

$$Y_{min} = 7.006 - (2.003 + 1.003 + 1.003 + 3.003$$
$$= 7.006 - 7.012 = - .006$$

The maximum dimension Y is determined from the minimum material limits as follows:

$$Y_{max} = 7.012 - (1.997 + 0.997 + 0.997 + 2.997) = + .024$$

The average dimension Y is determined as follows:

(1) Total tolerance = - .006 to + .024 = .030

(2) One-half total = .030/2 = .015

(3) Average = - .006 + .015 = + .009 or .024 - .015 = + .009

b. Class of Fit.

Since the minimum clearance is minus and the maximum clearance is positive, this is a transition fit.

Statistical Tolerancing

Actual Production Distributions

When a part is actually produced, the distribution of "lengths" in many cases follows a normal distribution. The distribution of parts may, therefore, be represented as shown in Figure 7 and Figure 8.

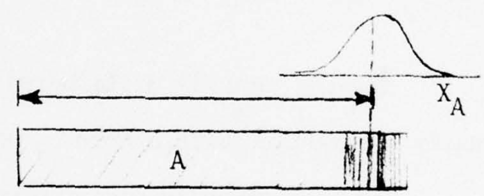


Figure 7

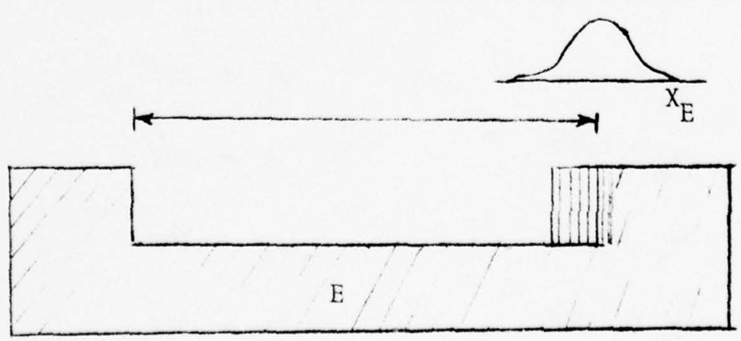


Figure 8

Linear Combinations of Random Variables

If (a) X_A, X_B, ... X_n are independent random variables having means μ_A, μ_B, ... , μ_n and variances $\sigma_{X_A}^2$, $\sigma_{X_B}^2$, ... , $\sigma_{X_n}^2$ respectively; (b) a_A , a_B , ... , a_n are constants; and (c) $Y = a_A X_A + a_B X_B + \ldots a_n X_n$, then Y is a random variable and

$$(1) \quad \mu_Y = E(Y) = E(a_A X_A + a_B X_B + \ldots + a_n X_n) = a_A X_A + a_B X_B + \ldots + a_n X_n$$

and

$$(2) \quad \sigma_Y^2 = E(Y-\mu_Y)^2 = a_A \sigma_A^2 + a_B \sigma_B^2 + \ldots + a_n \sigma_n^2$$

If X_A, X_B, ... , X_n are normally distributed random variables, then Y is also normally distributed with a mean μ_Y and variance σ_Y^2. Even if X_A, X_B, ... , X_n are not normally distributed, the distribution of Y approaches normality as n increases. (Central Limit Theorem).

Statistical Interchangeability

Refer to Figure 4 again and assume that the process producing parts A, B, C and D have a mean and standard deviation as follows:

$\mu_{X_A} = 3.000$	$\sigma_{X_A} = .002$
$\mu_{X_B} = 2.000$	$\sigma_{X_B} = .002$
$\mu_{X_C} = 3.000$	$\sigma_{X_C} = .002$
$\mu_{X_D} = 2.000$	$\sigma_{X_D} = .002$

This means that 99.7% of the parts produced will be within $\mu \pm 3\sigma$. In other words 99.7% of parts A produced will have a length dimension of $3.000 \pm .006$.

When the parts are assembled as shown in Figure 4, the length dimension Y of the "assemblies" can be calculated as follows:

$$\mu_Y = \mu_{X_A} + \mu_{X_B} + \mu_{X_C} + \mu_{X_D}$$

$$\text{or} \quad \bar{Y} = \bar{X}_A + \bar{X}_B + \bar{X}_C + \bar{X}_D$$

$$\bar{Y} = 3.000 + 2.000 + 3.000 + 2.000 = 10.000$$

and the variance and standard deviation of the distribution of the "assemblies" is calculated as follows:

$$\sigma_Y^2 = \sigma_{X_A}^2 + \sigma_{X_B}^2 + \sigma_{X_C}^2 + \sigma_{X_D}^2$$

$$\sigma_Y^2 = (.002)^2 + (.002)^2 + (.002)^2 + (.002)^2$$

Since $\sigma_{X_A} = \sigma_{X_B} = \sigma_{X_C} = \sigma_{X_D}$

Then $\sigma_Y^2 = 4\sigma_X^2 = 4(.002)^2 = .000016$

The distribution of the lengths of assemblies, Y, therefore has the parameters $\mu_Y = 10.000$ and $\sigma_Y^2 = .000016$ (or $\sigma_Y = .004$).

Therefore, 99.7% of the "assemblies" will be between $\mu_Y \pm 3\sigma_Y = 10.000 \pm .012$ or between 9.988 and 10.012.

Note that under the system of additive tolerancing (p. 12), a specification of $10.000 \pm .024$ would be specified if it were required that 100% of the "assemblies" meet the specifications. By

applying the concept of statistical tolerancing, the overall assembly specification can be greatly reduced.

A more practical application of statistical tolerancing would be one of the following:

(1) Assume that if 99.7% of the assemblies meet the specification, then this is an acceptable condition. Specify the "assembly" tolerance required (quality of design) and determine what the individual part tolerances would have to be to meet the assembly design criteria. An additional assumption would have to be made that 99.7% of the individual parts will meet these individual part tolerances. This is equivalent to saying that the "process capability" of $\pm$ 3σ or 6σ of the process distribution will equal the individual part tolerance.

<u>Example</u>

Refer to Figure 4 on p. 11. Assume that 99.7% of the assemblies must lie between 10.000 $\pm$ .024. Further assume that the tolerances to be calculated for X_A, X_B, X_C and X_D will equal exactly $6\sigma_X$ of the process producing these parts, and that this tolerance will be equal for all four parts. The problem then is to find the individual part tolerances, given an "assembly" tolerance of 10.000 $\pm$ .024 using the statistical tolerancing technique.

$$\sigma_Y{}^2 = \sigma_{X_A}{}^2 + \sigma_{X_B}{}^2 + \sigma_{X_C}{}^2 + \sigma_{X_D}{}^2$$

but $$\sigma_{X_A}{}^2 = \sigma_{X_B}{}^2 = \sigma_{X_C}{}^2 = \sigma_{Y_D}{}^2$$

Therefore $\sigma_Y{}^2 = 4\sigma_X{}^2$

$$6\sigma_Y = .048$$

or $$3\sigma_Y = .024$$

therefore $$\sigma_Y = .008$$

and $$\sigma_Y^2 = .000064$$

$$4\sigma_X^2 = \sigma_Y^2$$

$$4\sigma_X^2 = .000064$$

$$\sigma_X^2 = .000016$$

$$\sigma_X = .004$$

The individual part tolerances = $\pm\ 3\sigma_X = \pm\ .012$.

Compare this with the ± .006 tolerances obtained under the additive tolerancing technique (pages 11 and 12). Note that by using the statistical tolerancing technique and accepting that approximately 99.7%, rather than 100%, of the assemblies will meet the assembly specification, the individual part tolerance can be increased from ± .006 to ± .012 .

In general, as the tolerances get larger, the cost of producing the item decreases. The use of statistical tolerancing techniques can, therefore, result in decreased costs while still meeting the overall specification requirements.

(2) Suppose that Parts A, B, C, and D of Figure 4 are being produced to the tolerances indicated on p. 11. Further assume that the process producing these parts, produces them with the mean length indicated as the design size (3.000, 2.000, etc.), that

the distribution of lengths is Normal, and that $3\sigma_X$ of the distribution equals .006 or $6\sigma_X$ equals .012. In other words, 99.7% of the individual parts will meet the specified tolerances. Suppose that the assembly specification is 9.996 to 10.008. What percentage of "assemblies" will meet the assembly specification?

$$Y = \overline{X}_A + \overline{X}_B = \overline{X}_C + \overline{X}_D$$

$$\overline{Y} = 3.000 + 2.000 + 3.000 + 2.000$$

$$\overline{Y} = 10.000$$

$$6\sigma_X = .012$$

$$\sigma_X = .002$$

$$\sigma_Y^2 = \sigma X_A^2 + \sigma_{X_B}^2 + \sigma_{X_C}^2 + \sigma_{X_D}^2$$

$$\sigma_{X_A}^2 = \sigma_{X_B}^2 = \sigma_{X_C}^2 = \sigma_{X_D}^2 = \sigma_X^2 = (.002)^2$$

$$\sigma_Y^2 = 4\sigma_X^2$$

$$\sigma_Y^2 = 4(.002)^2$$

$$\sigma_Y^2 = .000016$$

$$\sigma_Y = .004$$

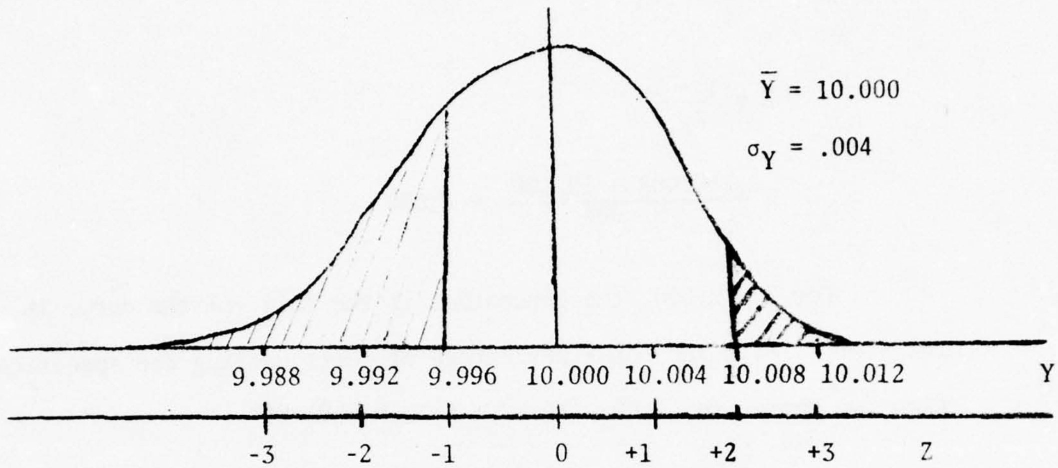


Figure 9

Distribution of Assemblies

Figure 9 shows the distribution of lengths of "assemblies." To determine what percentage of assemblies meets the specification, this specification must be superimposed on this distribution and the percentage obtained from a normal probability table.

The percentage of parts not meeting the lower specification is as follows:

$$Z = \frac{Y - \bar{Y}}{\sigma_Y}$$

$$Z = \frac{9.996 - 10.000}{.004} \qquad = - 1.000$$

For Z = -1.000, the area in the tail of a normal curve is .1587 or 15.87%.

The percentage of parts not meeting the upper specification is as follows:

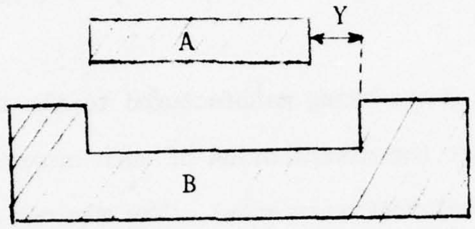
$$Z = \frac{Y - \overline{Y}}{\sigma_Y}$$

$$Z = \frac{10.008 - 10.000}{.004} = 2.000$$

For Z = 2.000, the percentage in the tail of the curve is .0228 or 2.28%. The total percentage of parts meeting the specification is, therefore, 1.00 - (15.87 + 2.28)% = 81.85%.

PROBLEM SET NO. 1

1. A manufacturer has received a contract to manufacture parts as shown below:



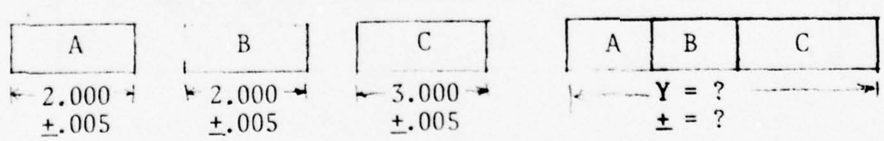
Part A must have a mean exterior dimension of 5 inches.

Part B must have a mean interior dimension of 5.03 inches.

The maximum clearance allowed (Y) is .04414 inches and the minimum clearance allowed (Y) is .01586 inches.

The manufacturer has a piece of equipment that can manufacture both Parts A and B and the "natural tolerance" of this piece of equipment is .06 (i.e., $6\sigma = .06$). What percentage of the parts produced will meet the specifications?

2. The following parts (A, B, and C) are being produced to the tolerances shown.



a. If we insist on 100% of the assembled parts meeting the specification, what tolerance should we set for the assembled part (A, B, and C)?

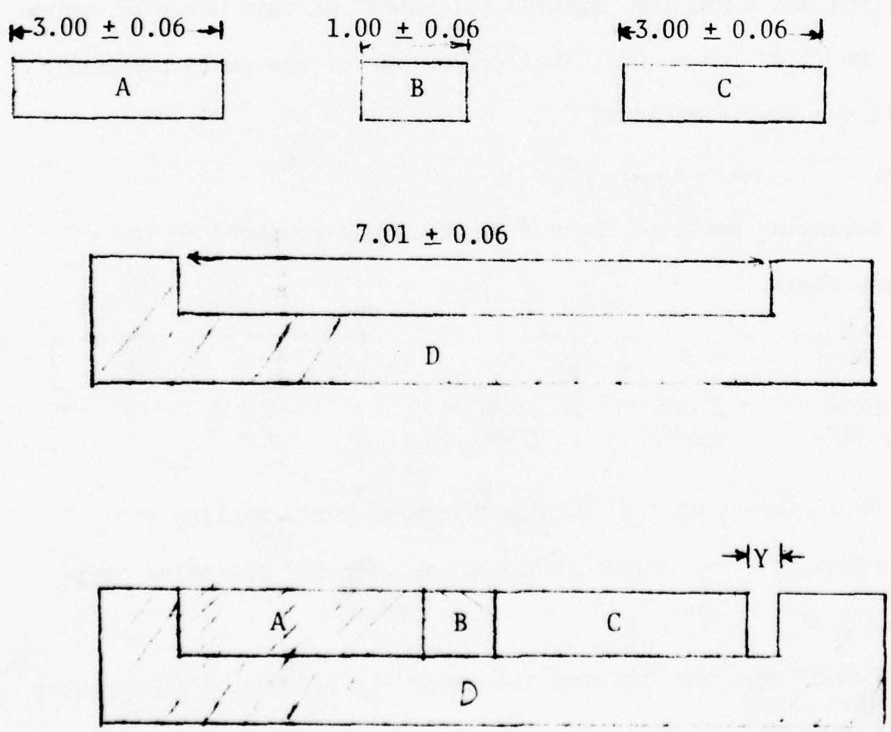
b. Assume that the "natural tolerance" (i.e., 6σ) of the process (machine) producing parts A, B, and C is equal to the total tolerance specified.

If we require that 99.7% of the parts fit the assembly spec, what tolerance should we set for the assembled part (A, B, and C)?

3. Parts A, B, C, and D are being manufactured to the tolerances shown below (assume that the distribution of each component produced is normal, with the total tolerance = 6σ). The minimum clearance (shown as Y on the drawing) is specified to be .002 inch and the maximum clearance is specified to be .014 inch.

a. What percent of the "assemblies" produced will have a "Y" fit that is too loose?

b. What percent will have a "Y" fit that is too tight?



4. Refer to Figure 6 on p. 14. Disregard the tolerances indicated in the example problem. The machine producing parts A, B, C, D, and E has a capability of producing parts with a total tolerance of 0.00537 (i.e., the process capability of $6\sigma_X = .00537$) for each part or component.

Using statistical tolerancing, answer the following:

a. What will be the minimum and maximum clearance for 99.7% of the assemblies (to 3 decimal places)?

b. Suppose that only assemblies with a Y dimension of .007 to .011 are acceptable. What percentage of the assemblies are acceptable?

CHAPTER 3

PROCESS CAPABILITY

Process

A "process" can be defined in several ways, two of which are as follows: (a) a systematic series of actions directed to some end, or (b) a continuous action, operation, or series of changes taking place in a definite manner (Barnhart, 1970).

Some examples of a process are: (a) the manufacture of a part, (b) the assembly of several parts, (c) typing a page, (d) preparing a supply requisition, (e) calibrating a piece of equipment, (f) keypunching a data processing card, and (g) repairing/maintaining a piece of equipment.

All of these processes can result in variation from the "standard." A part designed to be 10.000" may be 10.001". A supply requisition, data processing card, typewritten page, etc. may have one or more errors.

In quality control, we attempt to separate the variation that occurs in processes into two types. The first type is random variation. Random variation is also called "non-significant" variation, or variation that results from "non-assignable" causes. This type of variation occurs "at random" due to the inherent nature of the process and cannot be controlled. The other type of variation is due to "assignable" causes. It is called "assignable", "non-random", "findable", or "significant".

When a process has only random variation present, it is said to be "in control." It is performing at the highest level of which it is capable. When a process has other than random variation present, it is said to have variation due to one or more "assignable causes" and is said to be "out of control."

The remainder of this chapter will be concerned with determining the "process capability"--the amount of variation that will occur in a process due to random or "unassignable" or "uncontrollable" causes. The remaining chapters in this handout will be concerned with setting up a control system (statistical quality control charts) to monitor the process to detect when it is "out of control."

In discussing process capability and, later, statistical control charts, we will be concerned with two types of data. The first type will be called variables or measurements. This type of data applies to such items as "measuring" (a) the length or diameter of a part (e.g., 10.000"), (b) the resistance of a coil (e.g., 8 ohms), (c) the pressure in a tank (e.g., 352 psi), (d) the weight of an item (e.g., 600 lbs), etc. The second type of data is called "attributes" and involves a "counting" process. Examples of this type of data are: (a) defectives per lot, (b) defects (errors) per page, (c) defects (errors) per supply requisition, etc.

The first requirement in determining the process capability is to insure that the process is "in control" when the data is collected. This means that special care should be taken to insure that all "assignable" causes of variation have been removed. For example, this

might imply that the machine is maintained and calibrated properly and that it was being operated by a fully trained operator.

Process Capability - Variables or Measurements

To determine the process capability of this type of process is to determine the distribution of "measurements" produced by the process when the process is "in control," Normally, this distribution will not be significantly affected by the mean (μ) of the distribution, therefore, our primary concern is with the standard deviation of the distribution.

(a) σ_X Known. If the process has been in operation for a very long period of time and a large number of data elements collected, it may be considered that the standard deviation of the process is known, therefore, the process capability is considered known and statistical control charts can be based on the known population standard deviation. In this case

$$\sigma_X{}^2 = \frac{\Sigma(X-\mu)^2}{N}$$

$$\text{and} \quad \sigma_X = \sqrt{\frac{\Sigma(X-\mu)^2}{N}}$$

where : X = a measurement

μ = the population mean

N = the number of elements in the population

The process capability is usually defined as $6\sigma_X$. In other words, if the distribution is normal, almost all of the variation

(99.7%) will fall within $\mu \pm 3\sigma_X$. Therefore, the "process is capable" of producing (with only random variation) in a $6\sigma_X$ range.

(b) σ_X Unknown but Estimated from a Sample Standard Deviation. If the population standard deviation is unknown, it can be estimated from a sample taken from the population. The unbiased estimate ($\hat{\sigma}_X^{\,2}$) of the population variance ($\sigma_X^{\,2}$) is calculated as follows:

$$\hat{\sigma}_X = \frac{\sum_{1}^{n}(X_i - \bar{X})^2}{n-1}$$

and the standard deviation is:

$$\hat{\sigma}_X = \sqrt{\frac{\sum_{1}^{n}(X_i - \bar{X})^2}{n-1}}$$

Normally, we would pool all of the observations and compute $\hat{\sigma}_X$ with n equal to the total number of observations (i.e., estimate $\hat{\sigma}_X$ from one sample of size n, where n is the total number of observations. If, however, the process average shifts during the time the samples are being taken, $\hat{\sigma}_X$ will be inflated due to the change in mean and $\hat{\sigma}_X$ not be a good estimate of σ_X. To overcome this difficulty, we normally take a number of samples of size n (where n is now a much smaller number) and compute $\hat{\hat{\sigma}}_X$ from the standard deviation computed from each sample ($\hat{\sigma}_X$). If we collect k samples of size n and compute $\hat{\sigma}_X$ for each sample, then the average estimate is

$$\bar{\sigma}_X = \frac{\sum_{1}^{k}\hat{\sigma}_X}{k}$$

It has been shown that

$$E\left(\frac{\bar{\sigma}_X}{\sigma_X}\right) = c_2$$

or $$E\left(\frac{\bar{\sigma}_X}{c_2}\right) = \sigma_X$$ where values of c_2 for different sample sizes (n) are tabulated in Appendix 1. In other words, an unbiased estimate of σ_X is given by $\frac{\bar{\sigma}_X}{c_2}$, therefore, we can estimate the process capability by:

(a) Taking k samples of size n

(b) Computing $\hat{\sigma}_X$ as the standard deviation from each sample

(c) Computing $\bar{\sigma}_X$ as the average standard deviation

(d) Estimating the population standard deviation, σ_X by $\frac{\bar{\sigma}_X}{c_2}$ where c_2 is dependent on n. We will now call this new estimate of the population standard deviation $\hat{\hat{\sigma}}_X$, therefore,

$$\hat{\hat{\sigma}}_X = \frac{\bar{\sigma}_X}{c_2}$$

The process capability is now estimated as $6\hat{\hat{\sigma}}_X$. If the distribution is normal, then 99.7% of the measurements will fall in the range $\bar{\bar{X}} \pm 3\hat{\hat{\sigma}}_X$ where $\bar{\bar{X}}$ is the mean of the sample means.

CAUTION: Note that c_2 is dependent on the number of observations in each sample (n), not on the number of samples (k).

(c) σ_X Unknown but Estimated from the Range. If the population standard deviation is unknown, it can be estimated from the range. Since an extensive amount of computational effort is required to estimate σ_X from the sample standard deviation, $\hat{\hat{\sigma}}_X$ is frequently determined using the range from k samples.

The average range $(\bar{R})$ of k samples of size n can be computed by

$$\bar{R} = \frac{\sum_{1}^{k} R}{k}$$

It can be shown that an unbiased estimate of the population standard deviation can be obtained by

$$\hat{\sigma}_X = \frac{\bar{R}}{d_2}$$

where values of d_2 for different sample sizes (n) are tabulated in Appendix 1. The process capability is, therefore, $6\hat{\sigma}_X$.

CAUTION: Note that d_2 is dependent on the number of observations in each sample (n), not on the number of samples (k).

EXAMPLE

1. A manufacturing process consisted of winding a wire on a coil. The resistance of the coil was determined after the winding was complete and a measurement made as to the deviation (over or under) (in ohms) from the required standard. Ten samples of five coils each were selected at random from the line when the process was "in control." The following observations were taken:

Sample No.	COIL IN SAMPLE X_1	X_2	X_3	X_4	X_5
1	0	+2.0	+3.0	-2.0	-1.0
2	0	+2.0	0	-4.0	+1.0
3	-1.0	+3.0	+4.0	-1.0	0
4	+4.0	+1.0	-1.0	+2.0	+2.0
5	-2.0	0	0	-2.0	+1.0
6	+1.0	-1.0	0	0	-1.0
7	0	0	-1.0	+1.0	-1.0
8	-1.0	+2.0	-2.0	+4.0	0
9	-3.0	-2.0	-1.0	-3.0	+1.0
10	+5.0	+1.0	-2.0	0	-1.0

Determine the process capability by (a) estimating σ_X from the sample standard deviations, and (b) estimating σ_X from the sample ranges.

(a) $n = 5$ $k = 10$

Sample No.	$\hat{\sigma}_X$	Sample No.	$\hat{\sigma}_X$
1	2.07	6	.84
2	2.28	7	.84
3	2.35	8	2.40
4	1.81	9	1.68
5	1.34	10	2.71

$$\bar{\sigma}_X = \frac{\sum_1^k \hat{\sigma}_X}{k} = \frac{18.32}{10} = 1.832$$

$$\hat{\hat{\sigma}}_X = \frac{\bar{\sigma}_X}{c_2} = \frac{18.32}{.8407} = 2.179$$

An estimate of the process capability $= 6\hat{\hat{\sigma}}_X = 6(1.9483) = 11.690$

The best estimate of μ is $\bar{\bar{X}}$ (the mean of the sample means), therefore, for this problem an estimate of the process capability for this machine or process setting is

$$\bar{\bar{X}} \pm 3\hat{\hat{\sigma}}_X = .14 \pm 3(2.179)$$
$$= .14 \pm 5.845$$

(The actual mean and standard deviation from which this sample was drawn are as follows: $\mu = 0.00$; $\sigma_X = 1.715$)

(b) $n = 5$ $k = 10$

Sample No.	R	Sample No.	R
1	5	6	2
2	6	7	2
3	5	8	6
4	5	9	4
5	3	10	7

$$\overline{R} = \frac{\sum_{1}^{k} R}{k} = \frac{45}{10} = 4.5$$

$$\hat{\sigma}_X = \frac{\overline{R}}{d_2} = \frac{4.5}{2.326} = 1.9346$$

An estimate of the process capability = 6(1.9346) = 11.601.

Again, an estimate of the process capability for this machine or process setting is:

$$\overline{\overline{X}} \pm 3\hat{\sigma}_X = .14 \pm 3\ (1.9346) = .14 \pm 5.809$$

Process Capability - Attributes

(a) Fraction Defective. Many quality characteristics cannot be measured and expressed in numbers, but can only be classified as defective or non-defective. Sometimes we may want to classify the quality characteristic in this manner even though it can be measured. We may, for example, decide that if the resistance of a coil falls between 8 and 10 ohms, we will classify it as good, and if it does not, we will classify it as defective. Then, rather than measure the number of ohms resistance, we simply determine if it is between 8 and 10 ohms.

When an item can be classified into only two categories (i.e., when there are only two possible outcomes) we have a Bernouli process. If we have a population of items and a certain proportion of them are defective and a certain proportion are not, the proportion is called a parameter of the population--in this case, the fraction defective(Π). (Review statistics course material).

Later we will be concerned with taking samples of size n from populations such as this in order to estimate the population parameter (Π) by the proportion of items in the sample that possess the characteristic of interest (e.g., are defective).

The number of items in a sample size n that possess the characteristic of interest (e.g., are defective) follows a binomial distribution. For large values of n, the binomial distribution can be approximated by the normal distribution. In quality control we are concerned primarily with control charts based on the normal approximation to the binomial. The first question that the student usually asks the instructor is, "How large an n is large enough?" The answer is, "It depends on p." The student usually replies, "But I don't know what p is (you dummy), that's why I'm taking the sample--to estimate p."

A sample size of $n = 30$ is usually sufficient, however, a better rule appears to be that n should be large enough such that $np \geq 5$ <u>and</u> $n(1-p) \geq 5$. If, after taking a sample of 15 or 20, the above rules are not met (based on "p" estimated from the sample of 15 or 20), then the sample size should be increased. The student should review the material on Bernouli processes, binomial

distribution, and the normal approximation to the binomial taught in the two statistics courses. See example problem on page 39.

In summary, the process should first be brought into control, i.e., special precautions taken to eliminate all assignable causes of variation, then a sample of sufficient size should be taken and the percentage of defective items in the sample determined in order to estimate the percentage of defective items in the population. This estimate (p) of the population parameter (Π) is then used to set up statistical quality control charts to be described in a later chapter.

(b) Defects Per Unit. Sometimes we may not be interested in classifying an item as "good" or "defective", but rather we may be interested in determining the number of "defects per unit." For example, we may be interested in the number of defects per 100 feet of wire, the number of errors per supply requisition, the number of errors per typewritten page, the number of defects per square meter of material, etc. When classified in this manner, the number of defects per unit follows a Poisson distribution where the expected number of defects $E(r) = \lambda$. In quality control, we take samples of individual units (i.e., one unit constitutes a sample) and label the number of defects in each sample c_k where c = the number of defects in the k^{th} sample (unit). An estimate of λ is, therefore, $\bar{c}$, the average number of defects per unit. The student should review the material on the Poisson distribution taught in the statistics courses.

In setting up statistical quality control charts, the control limits are based on the value of $\bar{c}$ obtained from sampling units from the process.

Again, it is necessary to insure that the process is "in control" when taking the samples. See example problem on page 41.

Process Capability and Technical Specifications. In the chapter on statistical tolerancing we "assumed" that the tolerance was exactly equal to the process capability or $6\sigma_X$. In practice, however, the process capability may not be matched exactly to the tolerances specified. Suppose, for example, that a specification called for the length (X_A) of a part (A) to be 10.000 $\pm$ .003. Further, suppose that the only machine available to produce the part was one that had a process capability of 10.000 $\pm$ .006, i.e., σ_X = .002. If this process is used, the percentage of parts produced that do not meet the specification is determined as follows:

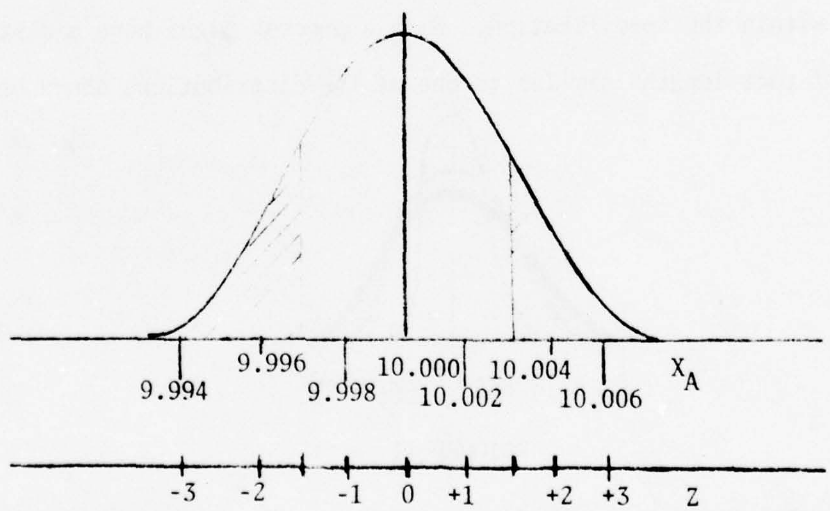


FIGURE 10

$$Z = \frac{X_A - \overline{X}}{\sigma_{X_A}} = \frac{10.003 - 10.000}{.002} = 1.5$$

Percentage of "good" parts = .866 or 86.6% of the parts will meet the specification and 13.4% will not. If this percentage of defective parts is too high to be acceptable, there are two alternatives.

(1) The parts can be produced using this process and the parts can be 100% inspected and "operationally sorted." Operational sorting is a planned manufacturing operation when a decision has been made to produce an item with a process that is not capable of meeting the specification with an acceptable percentage acceptance (or percentage defective).

(2) The parts can be produced by another process (or machine) that is capable of producing an acceptable percentage of parts within the specification. Such a process might have a distribution of part lengths similar to one of the distributions shown below.

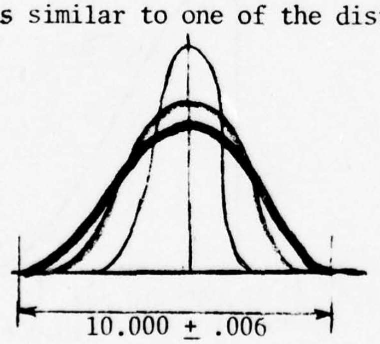


FIGURE 11

Operational Sorting vs a Different Process. The decision as to whether to operationally sort or use a different process is largely an economic one. Costs are increased when the parts must be 100% inspected and defective parts scrapped or reworked. Costs are also increased when

the process capability is made "tighter." Again, in general, as the specifications are made tighter, the costs of producing the item are increased.

Example Problem--Fraction Defective

One of the ALC's was collecting data on the number of defective engine sub-assemblies overhauled in order to construct an appropriate control chart. Every effort was made to insure that the process was in control. You were presented with the following sample data:

Sample Size 50

Sample No.	Number of Defective Sub-assemblies in the Sample
1	5
2	3
3	7
4	5
5	8
6	6
7	5
8	8
9	10
10	3

a. What type of sampling distribution does this represent?

Since this is a Bernouli process (the sub-assembly is "good" or it is "defective"), we have a binomial distribution.

b. What is the parameter of this distribution and what is your best estimate of the value of this parameter?

The parameter is Π (the fraction defective) and our best estimate is $\overline{p}$ which can be calculated as follows:

$$
\begin{aligned}
p_1 &= 5/50 = .10 \\
p_2 &= 3/50 = .06 \\
p_3 &= 7/50 = .14 \\
p_4 &= 5/50 = .10 \\
p_5 &= 8/50 = .16 \\
p_6 &= 6/50 = .12 \\
p_7 &= 5/50 = .10 \\
p_8 &= 8/50 = .16 \\
p_9 &= 10/50 = .20 \\
p_{10} &= 3/50 = .06
\end{aligned}
$$

$$\sum_1^{10} p_k = 1.20$$

$$\overline{p} = \frac{\sum_1^{10} p_k}{k} \quad \frac{1.20}{10} = .12$$

$$\text{or} \quad \overline{p} = \frac{5 + 3 + 7 + 5 + 8 + 6 + 5 + 8 + 10 + 3}{500}$$

$$= \frac{60}{500} = .12$$

Example Problem--Defects Per Unit

Base Supply was concerned with the number of errors being made on supply requisitions. A concerted effort was made to insure that all "assignable causes" for errors had been removed. A random sample of twenty requisitions was collected while the process was "in control." The following data were obtained for the sample.

Sample Requisition (k)	Number of Errors in Requisition (c_k)
1	0
2	1
3	3
4	2
5	5
6	0
7	3
8	2
9	1
10	0
11	0
12	4
13	6
14	0
15	3
16	1
17	2
18	1
19	0
20	1

$$\sum_{1}^{k} c_k = 35$$

a. What type of distribution characterizes this process?

Since we are concerned with defects per unit where the unit is a requisition and the defects are errors in the requisition, the distribution is Poisson.

b. What is the parameter of this distribution and what is your best estimate of the value of this parameter based on the sample data?

The parameter is λ (the mean number of errors per requisition) and our best estimate of λ is $\overline{c}$, the value of which is calculated as follows:

$$\overline{c} = \frac{\sum_{1}^{k} c_k}{k}$$

$$\overline{c} = \frac{35}{20} = 1.75$$

PROBLEM SET NO. 2

1. You have collected the sample data on resistances shown in the table on page 32 and have computed the "process capability" using the sample standard deviations shown on page 33. The specification calls for the resistances to be within a range of 0 ± 2.5 ohms. Based on the process capability computed from the sample, what percentage of parts will meet the specification?

2. Refer again to the sample data on resistances. Using the estimate of the process capability computed from the sample ranges, what percentage of parts will meet a specification of parts of 0 ± 3.0 ohms?

3. A process producing a certain submarine engine part was monitored closely to insure that the process was in control. The following data were taken from samples of the process when it was in control. (All data in inches)

		Sample 1	2	3	4	5
Observation	1	1.5012	1.5034	1.5042	1.5061	1.5038
	2	1.5130	.	.	.	.
	3	1.4916	.	.	.	.
	4	1.5066	.	.	.	.
	$\overline{X}$		1.5050	1.5032	1.5043	1.4994
	R		.0189	.0202	.0193	.0232

a. Compute $\overline{X}$ and R for sample No. 1.

b. What is your "best estimate" of the mean of the process?

c. What is your "best estimate" of the standard deviation of the process.

d. What is your estimate of the process capability (upper and lower limit) for this machine setting?

e. If the product specification required the part to be manufactured to a specification of 1.501 $\pm$ .01 inches, what percentage of parts would meet the specification?

4. The Air Force does not use "verifiers" on its key punch operations; therefore, errors can be expected to occur in these operations. You have a highly motivated, well trained set of operators who appear to be making the minimum number of errors possible when key punching supply requisitions. Over a period of several days, you take 5 samples of 100 requisitions per sample and check them thoroughly for errors.

SAMPLE NO.	NUMBER OF INCORRECT REQUISITIONS IN SAMPLE
1	9
2	6
3	7
4	10
5	8

Answer the following:

a. According to the data given above, when an inspector examines a requisition it can be classified in ______ of ______ possible ways. When an item can only be classified in ______ of ______ possible ways (and meets several other requirements), it is said to be a _________ process. When we have a number of _____________ processes, their

outcomes form a ________________ distribution. The parameter of this distribution is ________________ and is estimated by ________________________.

For the problem above, our best estimate of ______________, based on the sample data, is __________________.

5. The following data was collected on a process producing aircraft wing sections. The process is assumed to be in control. A defect is considered to be a rivet missing from the wing.

Wing No.	Missing Rivets per Wing
1	3
2	6
3	1
4	3
5	6
6	2
7	5
8	3
9	4
10	7

The frequency of the variable "missing rivets per wing" is probably characterized by a ______________ distribution with the parameter ______________. Our best estimate of the parameter ____________ is ________________ which takes on the value ____________ for the sample data in this problem.

6. An ALC overhaul facility repaired a certain aircraft component and then tested the electrical resistance of the component with a multimeter. The Director of Quality Control decided to set up appropriate control charts for the components based on the electrical resistance readings. Every effort was made to insure that the process was in control and samples of 3 components per sample were collected and measured as follows:

NOTE: The multimeter readings are in hundredths of an ohm.

SAMPLE NUMBER	COMPONENT	COMPONENT	COMPONENT	AVERAGE	RANGE
1	32	30	30		2
2	37	18	37	31	
3	50	35	36	40	15
4	57	24	75		51
5	49	6	24	26	
6	67	25	25	39	42
7	52	56	53	54	4
8	18	39	47		29
9	40	51	51	47	11
10	31	61	28	40	

a. Estimate the process capability using the sample standard deviations.

b. Estimate the process capability using the sample ranges.

c. If the technical specifications required the components to have a resistance of 40 ± 10 hundredths of an ohm, what percentage of the components will meet the specification?

CHAPTER 4

PROCESS CONTROL: BACKGROUND FOR CONTROL CHARTS

Up to this point we have been primarily concerned with establishing tolerances and determining the process capability. After the process capability has been determined, the problem becomes one of monitoring the process to insure that it stays "in control". We can, of course, inspect every item (part, requisition etc.) for defects, but the costs associated with 100% inspection are most often prohibitive. Even 100% inspection does not guarantee that all defective items will be found.

Since the cost of 100% inspection is often prohibitive, a decision is most often made to "sample" the process. From the sample information, an inference is made about the "state" of the process. Since it is a sample, the conclusion reached about the state of the process may be in error. In other words, we take a sample and test a hypothesis about the true state of the process using sample information. Based on the statistical test of the hypothesis, we reach some conclusion about the state of the process.

For example, we would hypothesize that the process producing part A in Figure 7 (p. 16) was centered at (had as the mean of its distribution) 3.000. Our null hypothesis would then be:

$$H_0 : \mu_0 = 3.000$$

and the alternate hypothesis would be that the process was not centered at 3.000 or $H_1 : \mu_1 \neq 3.000$

We would take a sample of parts, measure their length, and test the hypothesis.

In reaching a conclusion based on the test we can make two types of errors.

A type I error is the error made when we reject the null hypothesis when the null hypothesis is true. In other words we conclude that the process is "out of control" when, in fact, the process is "in control". We designate the probability of making this type of error as α.

A type II error is the error made when we do not reject the null hypothesis when, in fact, the null hypothesis is not true. In other words we conclude that the process is "in control" when, in fact, it is not. We designate the probability of making this type of error as β.

We can control the type I error simply by setting the level that we desire and establishing the rejection/acceptance regions accordingly. The β error however, is dependent on the following:

(a) α

(b) sample size, n

(c) actual process mean, μ

In order to assess the β error we have to establish and formulate the alternate hypothesis for a specific value of μ_1.

<u>The β error as α changes-Holding n and H_1 constant</u>

To illustrate the changes in the β error by varying α and holding n and H_1 constant, we refer to the process producing Part A

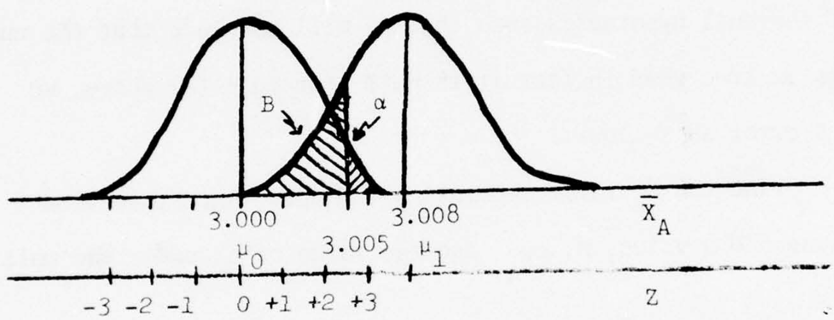
in Figure 7 on page 16 and formulate the following hypotheses.

(a) $H_0 : \mu_0 = 3.000$

$H_1 : \mu_1 = 3.008$

$\alpha = .006 \qquad \sigma_{X_A} = .002$

$Z = 2.5 \qquad n = 1$

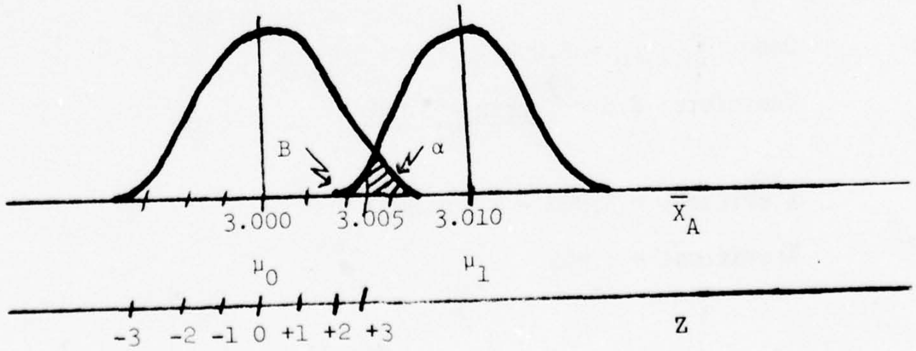


(b) $H_0 : \mu_0 = 3.000$

$H_1 : \mu_1 = 3.010$

$\alpha = .006 \qquad \sigma_{X_A} = .002$

$Z = 2.5 \qquad n = 1$



In order to determine the β error, we have to find out what percentage of the distribution of the alternate hypothesis lies in the acceptance region of the null hypothesis. In other words, if the process is, in fact, centered at the value stated in the alternate hypothesis, what percentage of this distribution lies in the acceptance region of the null hypothesis such that we will conclude that the null hypothesis is true when in fact it is not? For case (a) above, we find the β error as follows:

Find the $\overline{X}_A$ value separating the acceptance/rejection region using the α value, n, $\sigma_{\overline{X}_A}$ and the value of μ_0 under the null hypothesis.

$$Z = \frac{\overline{X}\text{ crit} - \mu_0}{\sigma_{\overline{X}}}$$

For $\alpha = .006$ $\quad Z = 2.5$

For $\sigma_{X_A} = .002$ and $n = 1$, $\sigma_{\overline{X}_A} = \frac{\sigma_{X_A}}{\sqrt{n}} = \frac{.002}{\sqrt{1}} = .002$

Under H_0, $\mu_0 = 3.000$

Therefore, $2.5 = \frac{\overline{X}\text{ crit} - 3.000}{.002}$

$\overline{X}$ critical $= 3.000 + 2.5\,(.002)$

$\overline{X}$ critical $= 3.005$

We have now established that $\overline{X}$ critical = 3.005. Now the problem is to find the β error using the $\overline{X}$ critical just determined

and the μ_1 and the $\sigma_{\overline{X}_A}$ under the alternate hypothesis.

$$Z = \frac{\overline{X}\text{ crit} - \mu_1}{\sigma_{\overline{X}_A}}$$

$$Z = \frac{3.005 - 3.008}{.002} = \frac{-.003}{.002} = -1.5$$

$\beta = .0668$ or 6.68%

For case (b) above, we find β as follows:

$\overline{X}$ critical will not change, therefore, $\overline{X}$ critical = 3.005

$$Z = \frac{3.005 - 3.010}{.002} = \frac{.005}{.002} = 2.5$$

$\beta = .006$ or 0.6%

Note that as the value of μ_1 under the alternate hypothesis moves further from μ_0 under the null hypothesis, the value of β decreases.

<u>The β Error as α Changes - Holding n and H_1 Constant</u>

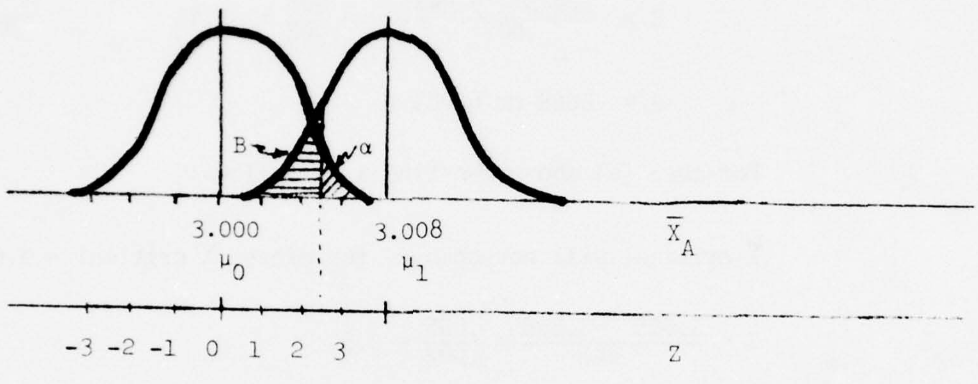
Again, we refer to the process producing Part A in Figure 7 on page 16 and formulate the following hypotheses:

(a) $H_0 : \mu_0 = 3.000$

$H_1 : \mu_1 = 3.008$

$\alpha = .006$ $\quad\sigma_{X_A} = .002$

$Z = 2.5$ $\quad n = 1$

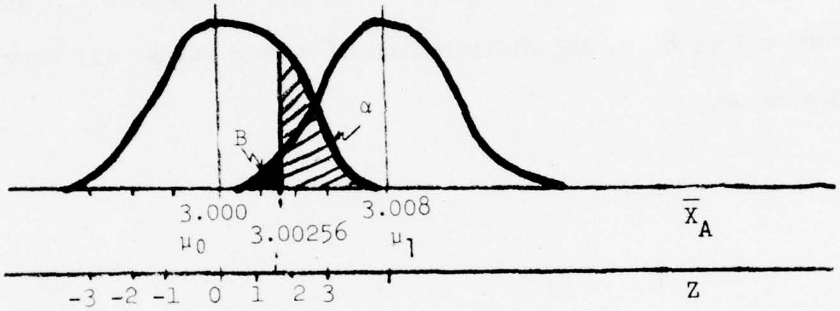

B
α
3.000
μ_0
3.008
μ_1
$\bar{X}_A$
-3 -2 -1 0 1 2 3
Z

(b) $H_0 : \mu_0 = 3.000$

$H_1 : \mu_1 = 3.008$

$\alpha = .10 \quad \sigma_{X_A} = .002$

$Z = 1.28 \quad n = 1$



For case (a), β remains 6.68%

For case (b), β is found as follows:

$$\bar{X}\text{ crit} = \mu_0 + Z\sigma_{X_A}$$

$$\bar{X}\text{ crit} = 3.000 + 1.28\ (.002)$$

$$= 3.00256$$

$$Z = \frac{3.00256 - 3.008}{.002} \qquad 2.72$$

$\beta = .00326$ or 0.326%

As α increases, β decreases.

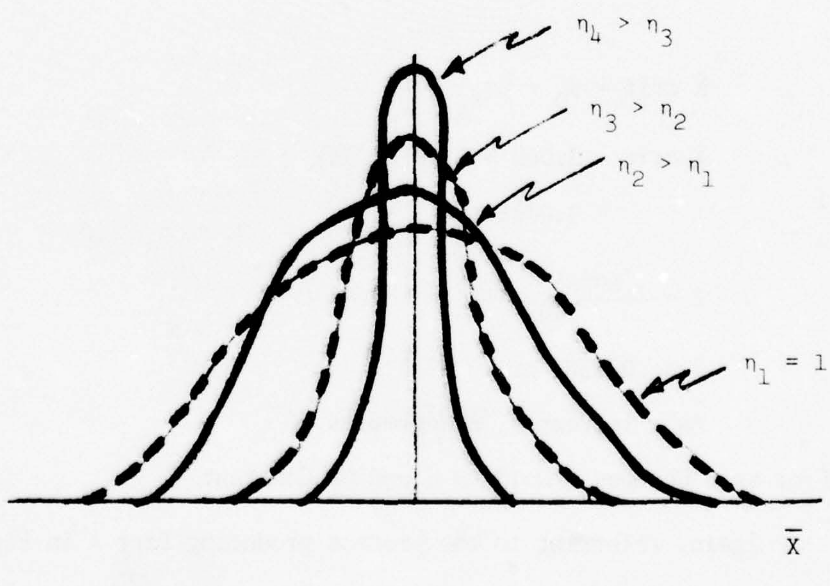
The β Error as n Changes - Holding α and H_1 Constant

Again, referring to the process producing Part A in Figure 7 on page 16, we are concerned now with the effect of changing n while holding α and H_1 constant. The standard deviation of a sampling dis-

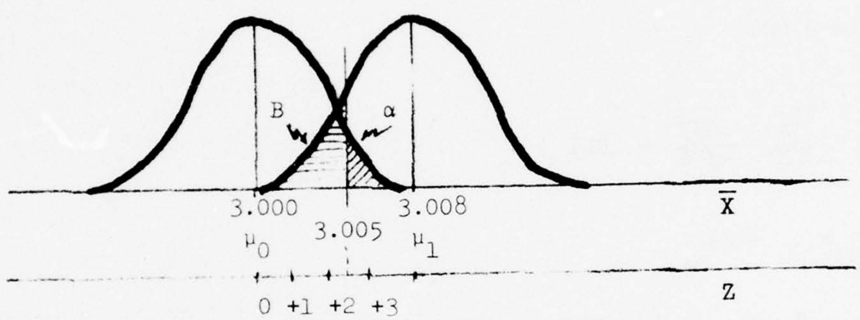
tribution (the distribution of the <u>means</u> of samples) varies with n as follows:

$$\sigma_{\overline{X}} = \frac{\sigma_X}{\sqrt{n}}$$

As a result, if we sample from the same population with different values of n, the distribution of sample means will vary as shown below.



(a) For this case, we simply refer to case (a) in the previous two sections, therefore β = 6.68%.



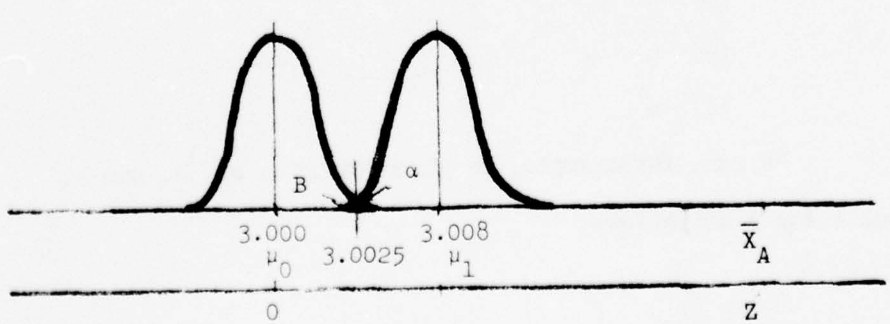
(b) For this case, we assume that n equals 4.

$H_o : \mu_o = 3.000$

$H_1 : \mu_1 = 3.008$

$\alpha = .006 \qquad \sigma_{X_A} = .002$

$n = 4$



Since n has changed, $\overline{X}$ critical has changed and must be recalculated as follows:

$$Z = \frac{\overline{X}_{crit} - \mu_0}{\sigma_{\overline{X}_A}}$$

For α = .006, Z = 2.5

$$\mu_0 = 3.000$$

$$\sigma_{\overline{X}_A} = \frac{\sigma_{X_A}}{\sqrt{n}} = \frac{.002}{\sqrt{4}} = .001$$

$$\overline{X}_{crit} = \mu_0 + Z\sigma_{\overline{X}_A}$$

$$= 3.000 + 2.5\ (.001)$$

$$= 3.0025$$

The β error is now calculated as follows:

$$Z = \frac{3.0025 - 3.008}{.001} = 5.5$$

β error = .0000000190 or .00000190%

Therefore, as n increases, β decreases.

Given μ_0 under H_0, μ_1 under H_1, and σ_X, we can then find any one of the following if the other two are specified:

(a) α

(b) β

(c) n

We can, for example, be given the μ's, σ_X, α, and β, and solve for n as follows:

Assume that we wanted the process centered at 3.000

$$H_0 : \mu_0 = 3.000$$

Assume that we wanted to detect if the process shifted to 3.001

$$H_1 : \mu_1 = 3.001$$

with an α risk = 0.05 and β = .20. Assume σ_{X_A} = .002. Find n.

$$\overline{X}_{crit} = \mu_0 + Z\sigma_{\overline{X}_A}$$

For α = .05, Z = 1.645

$$\overline{X}_{crit} = 3.000 + 1.645 \frac{.002}{\sqrt{n}}$$

For β = .20 , Z = .84

Therefore, to find n:

$$Z = \frac{\overline{X}_{crit} - \mu_1}{\sigma_{\overline{X}}} = \frac{\left(3.000 + \frac{.00329}{\sqrt{n}}\right) - 3.001}{\frac{.002}{\sqrt{n}}}$$

$$-.84 = \frac{-.001 + \frac{.00329}{\sqrt{n}}}{\frac{.002}{\sqrt{n}}}$$

$$\frac{(-.84)(.002)}{\sqrt{n}} = -.001 + \frac{.00329}{\sqrt{n}}$$

$$-\frac{.00168}{\sqrt{n}} - \frac{.00329}{\sqrt{n}} = -.001$$

$$\frac{.00497}{\sqrt{n}} = .001$$

$$\sqrt{n} = \frac{.00497}{.001} = 4.97$$

$$n = 24.7$$

Since we cannot take a sample of size 24.7, we must go to 24 or 25. If we go to 25, the β error will decrease as follows:

$$\bar{X}_{crit} = 3.000 + 1.645 \frac{.002}{\sqrt{25}}$$

$$= 3.000658$$

For the β error

$$Z = \frac{3.000658 - 3.0010}{\frac{.002}{\sqrt{25}}} = \frac{-.000342}{\frac{.002}{\sqrt{25}}} = -.855$$

Therefore, $\beta \approx 19.63\%$

Operating Characteristic (OC) Curves

The relationships among μ_0, μ_1, α, β, and n have been presented in the form of Operating Characteristic or OC curves thereby reducing the computations significantly. OC curves have been "standardized" in order to use the same curves for various values of μ_0 and μ_1 as follows:

$$d = \frac{\mu_1 - \mu_0}{\sigma_X}$$

OC curves for a one-sided test on the mean of a normal distribution with α = .05 are shown in Figure 12. Many different OC curves can be found in Engineering Statistics by Bowker and Lieberman.

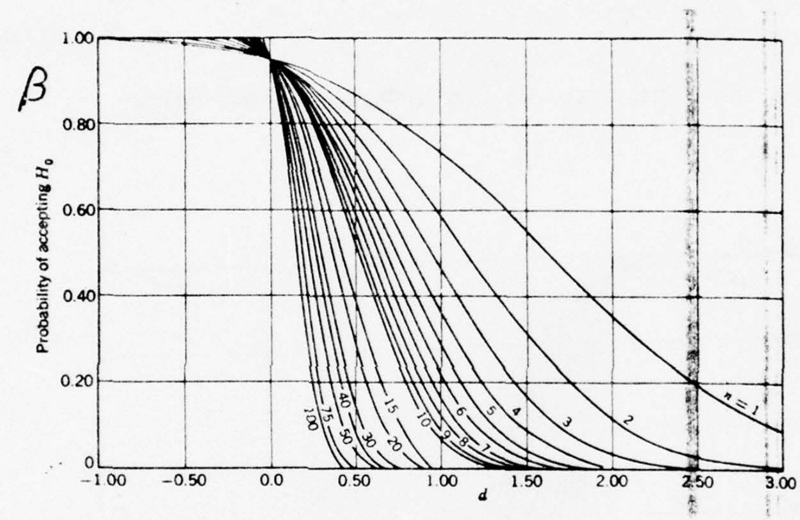


Figure 12

OC curves for different values of n for the one-sided normal test for a level of significance α = 0.05. From R. H. Bowker and G. J. Lieberman (1959), Engineering Statistics, Prentice Hall, Englewood Cliffs, NJ, p. 118.

Example

Refer to the previous example on page 56 wherein we solved for n. Using the OC curve, we can solve for n as follows:

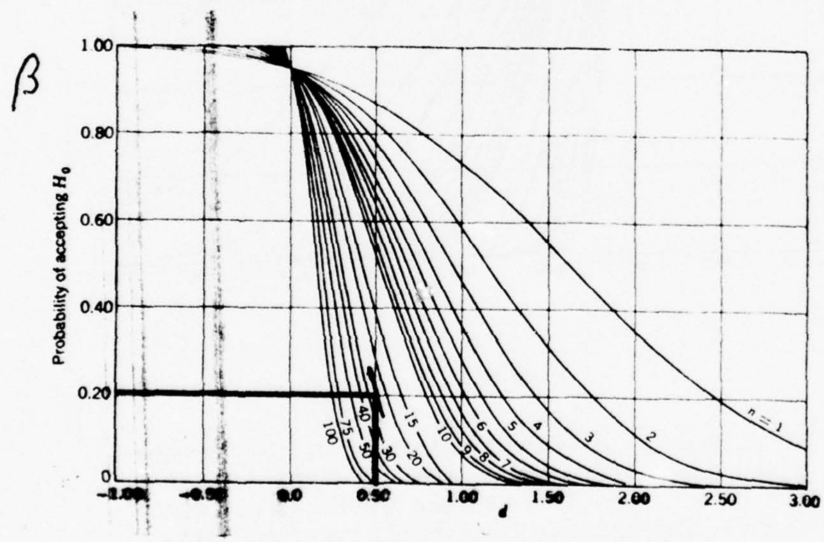
$$d = \frac{3.001 - 3.000}{.002} = \frac{.001}{.002} = .5$$

For d = .5

$\alpha = .05$

$\beta = .20$

and a one-sided test, we find $n \approx 25$ as shown below:



Example

Given $\mu_0 = 4.000$, $\mu_1 = 4.002$, $\sigma_X = .001333$, $\alpha = .05$, one-sided test, n = 2, find β.

$$d = \frac{4.002 - 4.000}{.001333} = 1.5$$

$\beta \approx .31$

Specifying α, β, and n

We have shown that α, β, and n are interrelated. For example, we can decrease β by increasing n or increasing α. We can decrease n by increasing β (keeping α constant).

The problem, however, is that there are costs associated with α, β, and n. If we increase n, we increase the costs of inspection. If we increase α, we will conclude a greater percentage of time that the process is out of control when it is not and we will incur additional costs looking for assignable causes when they do not exist. If we increase β, we will conclude that the process is in control a higher percentage of time when it is actually not in control and will produce a larger percentage of defective items. The choice, therefore, of α, β, and n is largely an economic one.

There are other considerations, however, In the space program, for example, we may be willing to accept a large α error in order to get a small β error to insure that the parts that we actually accept are not defective. In other words, we may be willing to reject a large number of "good lots" of parts in order to insure that we did not produce a lot when the process was out of control.

Summary

Once we have determined the process capability, we must monitor the process to insure that it remains "in control".

Accomplishing a 100% inspection of the items processed is often prohibitive from a cost standpoint. Therefore, we resort to sampling. When we sample, we have less than complete information.

Therefore, we may reach an incorrect conclusion based on the sample information. Specifically, we can make two types of errors. A Type I error is made when we conclude that a process is out of control when it is not. In other words, we will go looking for an assignable cause for the deviation when, in fact, there was not a deviation. The probability of this type of error we denote as α. A Type II error is made when we conclude that the process is in control, when, in fact, it is not. The probability of this type of error we denote as β.

Given values for μ_0, μ_1, and σ_X, we can find the value of any one of the following three items if we know the other two.

(1) α

(2) β

(3) n

In order to minimize the calculations, Operating Characteristics (OC) curves have been developed which show the relationship of these items.

The choice of α, β, and n are usually dependent upon the cost of sampling and the cost of making Type I and Type II errors.

PROBLEM SET NO. 3

1. An ALC overhaul process reconditioning Part A in Figure 1 on Page 2 should be set such that the mean of the distribution of lengths (X_A) is at 10.000. The standard deviation of the process is .004. In order to insure that the process is maintained "in control", a sample of n items will be taken. The following conditions are desired:

(1) Probability of a Type I error: 0.05

(2) If the process mean is at 10.008, the probability of a Type II error should be 0.12

Required:

(a) Find n by appropriate calculations.

(b) Find n using OC curve in Figure 12.

2. Refer to Problem No. 1. If β changes to 0.35, what is new n (using OC curves)?

3. We rarely use a sample size of one, but more often go to at least four or five. Thinking back to the Statistics I course, what is the <u>most important</u> reason for having the sample size at least four or five?

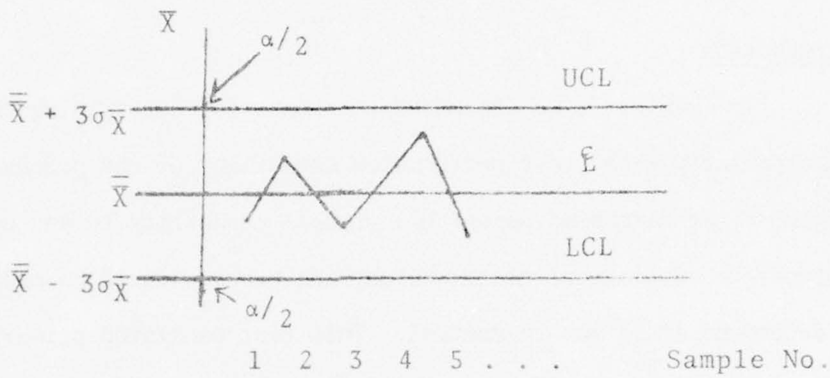
CHAPTER 5

PROCESS CONTROL: CONTROL CHARTS FOR VARIABLES OR MEASUREMENTS

Introduction

In Chapter 3, we discussed the means for determining the "process capability"--the best performance capability of the process. In Chapter 4, we discussed using this process capability to set up appropriate statistical tests whereby the process could be monitored to determine if it was in control. This test consisted primarily of determining an appropriate α level and sample size (n) and setting up appropriate acceptance/rejection regions. Periodic samples could then be taken, the sample values compared with the acceptance/rejection regions, and an inference made about the "state" of the process.

We can leave it at that and accomplish the quality control function in that manner. A better method, however, is to rotate the axis of the graph on which the distribution function, mean, acceptance/rejection regions, etc. are plotted. The centerline, and lines separating the acceptance/rejection regions are extended, the sample numbers are now plotted on the X axis and the "measurement" on the Y axis. We now have a statistical quality control chart as shown below. The distribution of $\bar{X}$'s is shown to illustrate how the Upper Control Limit (UCL), Lower Control Limit (LCL) and centerline (℄) are determined. It is not normally shown on an actual control chart. The sample values are now plotted on the chart. It can be immediately determined if the



process is "in control" or "out of control". The control chart provides the added advantage of highlighting any "trends" in the process.

$\overline{X}$ Charts

In Chapter 3, we discussed three methods of determining the process capability. Likewise, there are three methods of determining the control limits for an $\overline{X}$ chart, where $\overline{X}$ is the mean of a sample of n measurements.

(1) σ_X known

If the process standard deviation is known, the $\overline{X}$ critical and, therefore, the UCL and LCL are determined as follows:

$$X_{critical} = \mu_0 \pm 3\sigma_{\overline{X}}$$

but $$E(\overline{X}) = \mu$$

and $$\sigma_{\overline{X}} = \frac{\sigma_X}{\sqrt{n}}$$

Therefore, $X_{critical} = \bar{\bar{X}} \pm \frac{3\sigma_X}{\sqrt{n}}$

or $\qquad \bar{X} \pm (3/\sqrt{n})\sigma_X$

Values for $3/\sqrt{n}$ have been tabulated for various n and are denoted as A in Appendix A.

The control limits, therefore, are:

$$UCL : \bar{\bar{X}} + A\sigma_X$$
$$LCL : \bar{X} - A\sigma_X$$
$$\text{Ȼ} = \bar{\bar{X}}$$

(2) σ_X Unknown but Estimated from the Sample Standard Deviation.

We have shown in Chapter 3 that if σ_X is unknown, it can be estimated by $\hat{\sigma}_X = \frac{\bar{\sigma}_X}{c_2}$.

The control limits are, therefore, determined as follows:

$$X_{critical} = \mu_0 \pm 3\sigma_{\bar{X}}$$

but $\qquad E(\bar{\bar{X}}) = \mu_0$

and $\qquad \sigma_{\bar{X}} = \frac{\hat{\sigma}_X}{\sqrt{n}}$

but $\qquad \hat{\sigma}_X = \frac{\bar{\sigma}_X}{c_2}$

therefore

$$\sigma_{\bar{X}} = \frac{\frac{\bar{\sigma}_X}{c_2}}{\sqrt{n}} = \frac{\bar{\sigma}_X}{c_2\sqrt{n}}$$

therefore $X_{critical} = \bar{\bar{X}} \pm 3(\frac{\bar{\sigma}_X}{c_2\ n})$

or $\bar{\bar{X}} \pm (\frac{3}{c_2\sqrt{n}})\bar{\sigma}_X$

Values for $(\frac{3}{c_2\sqrt{n}})$ have been tabulated for various n and are denoted as A_1 in Appendix 1.

The control limits, therefore, are:

$$UCL = \bar{\bar{X}} + A_1\bar{\sigma}_X$$

$$LCL = \bar{X} - A_1\bar{\sigma}_X$$

$$℄ = \bar{\bar{X}}$$

(3) σ_X Unknown but Estimated from the Sample Range

We have shown in Chapter 3 that if σ_X is unknown, it can be estimated by $\hat{\sigma}_X = \frac{R}{d_2}$.

The control limits are, therefore, determined as follows:

$$X_{critical} = \mu_o \pm 3\sigma_{\bar{X}}$$

but $E(\bar{\bar{X}}) = \mu_o$

and $\sigma_{\bar{X}} = \frac{\hat{\sigma}_X}{\sqrt{n}}$

but $\hat{\sigma}_X = \frac{\bar{R}}{d_2}$

therefore $\sigma_{\bar{X}} = \frac{\frac{\bar{R}}{d_2}}{\sqrt{n}} = \frac{\bar{R}}{d_2\sqrt{n}}$

therefore $X_{critical} = \bar{\bar{X}} \pm 3(\frac{\bar{R}}{d_2\sqrt{n}})$

or $\bar{\bar{X}} \pm (\frac{3}{d_2\sqrt{n}})\ \bar{R}$

Values for $(\frac{3}{d_2\sqrt{n}})$ have been tabulated for various n and are denoted as A_2 in Appendix 1.

The control limits, therefore, are:

$$UCL : \bar{\bar{X}} + A_2\bar{R}$$

$$LCL : \bar{\bar{X}} - A_2\bar{R}$$

$$\text{Ȼ} : \bar{\bar{X}}$$

The $\bar{X}$ charts are used to insure that the process average does not shift from the desired setting. If the process average shifts, a higher percentage of items will fall outside of the previously established process capability limits for the desired μ_0 .

Even though the mean of the process might not shift, the process variability or the standard deviation (σ_X) of the process might change. This change would (if σ_X increased) result in a larger percentage of items falling outside of the desired values. This change would not be detected by the $\bar{X}$ chart.

Therefore, in order to detect shifts in the "process variability," standard deviation charts and range charts have been developed. One of these (usually the range chart) is often used in conjunction with the $\bar{X}$ chart.

Standard Deviation Chart

(1) σ_X known

In the statistics courses, you should have learned that the distribution of sample variances follows a chi-square distribution. It can be shown that over 99% of the $\hat{\sigma}_X$ values fall within the interval

$$E(\hat{\sigma}_X) \pm 3\sigma_{\hat{\sigma}_X}$$

In Chapter 3 it was shown that

$$\sigma_X = \frac{E(\hat{\sigma}_X)}{c_2}$$

or $$E(\hat{\sigma}_X) = \sigma_X c_2$$

It can also be shown that

$$\sigma_{\hat{\sigma}_X} = \left(\frac{\sqrt{2(n-1)-2nc_2^2}}{\sqrt{2n}}\right)\sigma_X$$

Therefore

$$E(\hat{\sigma}_X) \pm 3\sigma_{\hat{\sigma}_X}$$

can be replaced by

$$c_2\sigma_X \pm 3\left(\frac{\sqrt{2(n-1)-2nc_2^2}}{\sqrt{2n}}\right)\sigma_X$$

The upper control limit is:

$$c_2\sigma_X + 3\left(\frac{\sqrt{2(n-1)-2nc_2^2}}{\sqrt{2n}}\right)\sigma_X$$

We can factor out σ_X and replace what's left in the brackets by the constant B_2 for various values of n and have:

$$\left[c_2 + 3\left(\frac{\sqrt{2(n-1)-2nc_2^2}}{\sqrt{2n}}\right)\right]\sigma_X = B_2\sigma_X$$

where values of B_2 for various n are tabulated in Appendix 1. The lower control limit is calculated in a similar fashion except that in the brackets we have $[c_2 - 3 \ldots] = B_1\sigma_X$ where values of B_1 for various n are tabulated in Appendix 1.

Summary:

$$UCL = B_2\sigma_X$$

$$LCL = B_1\sigma_X$$

(2) σ_X unknown but estimated by $\dfrac{\bar{\sigma}_X}{c_2}$

If σ_X is unknown but estimated from k samples of size n by $\dfrac{\bar{\sigma}_X}{c_2}$, the we can replace σ_X by $\dfrac{\bar{\sigma}_X}{c_2}$ in the control limits computed in the preceding section and have

$$(c_2)\left(\frac{\bar{\sigma}_X}{c_2}\right) \pm 3\left(\frac{\sqrt{2(n-1)-2nc_2^2}}{\sqrt{2n}}\right)\left(\frac{\bar{\sigma}_X}{c_2}\right)$$

We can factor out $\bar{\sigma}_X$ and replace what's left in the brackets by the constant B_4 for the upper control limit and B_3 for the lower control limit as follows:

$$\left[1 \pm \left(\frac{3}{c_2}\right)\left(\frac{\sqrt{2(n-1)-2nc_2^2}}{\sqrt{2n}}\right)\right]\bar{\sigma}_X$$

$$UCL = B_4\ \bar{\sigma}_X$$

$$LCL = B_3\ \bar{\sigma}_X$$

Range Chart

It is easier to calculate the range of a sample than it is to calculate the standard deviation, therefore

the Range chart is used in conjunction with the $\bar{X}$ chart more frequently than is the standard deviation chart.

(1) σ_X Known

The distribution of the Range follows approximately the Chi-Square distribution. It can be shown that over 99% of the sample Range values lie within the interval

$$E(R) \pm 3\sigma_R$$

but $\quad E(R) = d_2\sigma_X$

and it can be shown that

$$\sigma_R = d_3\sigma_X$$

where values of d_3 for various n are tabulated in Appendix 1.

The control limits are, therefore:

$$d_2\sigma_X \pm 3d_3\sigma_X$$

We can factor out σ_X to get the following control limits:

$$UCL = (d_2 + 3d_3)\sigma_X$$
$$= D_2\sigma_X$$
$$LCL = (d_2 - 3d_3)\sigma_X$$
$$= D_1\sigma_X$$

where values for D_1 and D_2 for various n are tabulated in Appendix 1.

(2) σ_X Unknown and Estimated by $\frac{\bar{R}}{d_2}$

Again we have

$$E(R) \pm 3\sigma_R$$

but $\quad E(R) = \overline{R}$

and $\quad \sigma_R = d_3\sigma_X = (d_3)(\frac{R}{d_2})$

therefore the control limits are

$$\overline{R} \pm (3)(d_3)(\frac{\overline{R}}{d_2})$$

or $\quad \overline{R} \pm (\frac{3d_3}{d_2})\overline{R}$

If we factor out $\overline{R}$, we have

$$UCL = (1 + \frac{3d_3}{d_2})\overline{R}$$

$$= D_4\overline{R}$$

$$LCL = (1 - \frac{3d_3}{d_2})\overline{R}$$

$$= D_3\overline{R}$$

where values for D_3 and D_4 for various n are tabulated in Appendix 1.

Example

1. Refer to the example on page 32 and page 33.

(a) Determine the control chart limits for an $\overline{X}$ chart and a σ chart for the data in part (a).

Data: $n = 5$

σ_X Unknown

$A_1 = 1.596$

$B_3 = 0$

$B_4 = 2.089$

$\overline{\overline{X}} = .14$

$\overline{\sigma}_X = 1.638$

(1) $\overline{X}$ chart

$\mathcal{E} = \overline{\overline{X}} = .14$

$UCL = \overline{\overline{X}} + A_1\overline{\sigma}_X$

$= .14 + (1.596)(1.638) = 2.7542$

$LCL = \overline{\overline{X}} - A_1\overline{\sigma}_X$

$= .14 - (1.596)(1.638) = -2.4742$

(2) σ_X chart

$UCL = B_4\overline{\sigma}_X$

$= (2.089)(1.638) = 3.4217$

$LCL = B_3\overline{\sigma}_X$

$= (0)\ (1.638) = 0$

(b) Determine the control chart limits for an $\overline{X}$ chart and a R chart for the data in part (b).

<u>Data</u>: $n = 5$

σ_X Unknown

$A_2 = 0.577$

$D_3 = 0$

$D_4 = 2.115$

$\overline{R} = 4.5$

(a) <u>$\overline{X}$ chart</u>

$$℄ = \overline{\overline{X}} = .14$$

$$UCL = \overline{\overline{X}} + A_2\overline{R}$$

$$= .14 + (0.577)(4.5) = 2.7365$$

$$LCL = \overline{\overline{X}} - A_2\overline{R}$$

$$= .14 - (0.577)(4.5) = -2.4565$$

(b) <u>R chart</u>

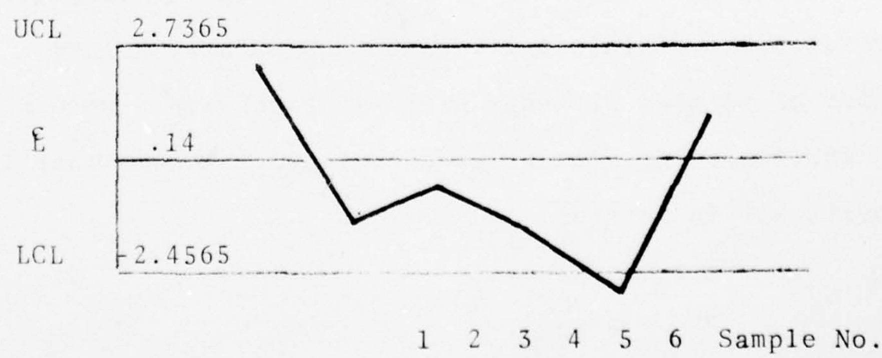
$$UCL = D_4\overline{R} = (2.115)(4.5) = 9.5175$$

$$LCL = D_3\overline{R} = (0)(4.5) = 0$$

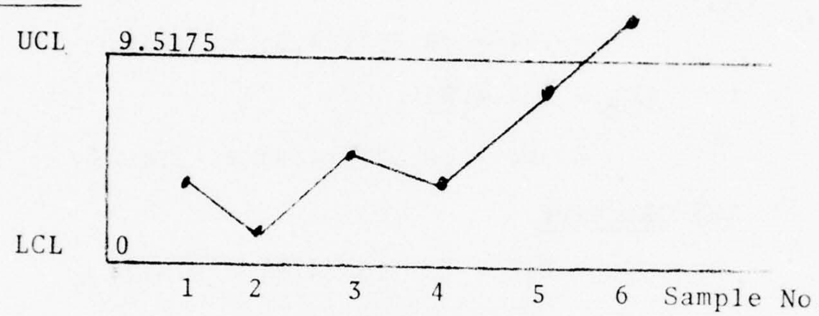
(c) Draw the control charts for part (b) above and the following sample values. Note: $n = 5$

Sample No.	$\overline{X}$	R
1	2.3	3
2	-1.6	2
3	-1.3	5
4	-1.9	4
5	-2.7	9
6	+.30	11

$\overline{X}$ chart



R chart



(d) What does sample No. 5 indicate?

Ans. Process mean (μ) has probably shifted causing the process to be out of control. Look for assignable cause.

(e) What does sample No. 6 indicate?

Ans. Process variability (σ) has probably increased causing the process to be out of control. Look for assignable cause.

Problem Set No. 4

#1

A certain aircraft part is being manufactured on a special piece of industrial plant equipment. A large number of samples with six parts in each sample were chosen and the following statistics calculated. Assume that the process was in control.

$\overline{\overline{X}}$ = 24.7 in.

$\overline{R}$ = .18 in.

a. Find the control limits for $\overline{X}$ and R for control charts based on these data.

b. What is your best estimate of the population standard deviation from which these samples were drawn?

c. If the <u>product specification</u> required the part to be manufactured to a specification of 24.7 $\pm$ .2 in., does the process meet these specifications? Show how you checked this. Assume process is in control.

#2

Refer to Problem No. 3 in Problem Set No. 2.

a. Compute the control limits for $\overline{X}$ and R charts and draw the charts.

b. After the control limits were established and the process running smoothly for some time, a series of samples yield the following results: What action would you take after you had collected <u>each</u> <u>sample</u>?

(1) $n = 4$, $\overline{X} = 1.512$ $R = .0264$ Action?

(2) $n = 4$, $\overline{X} = 1.538$ $R = .0280$ Action?

(3) $n = 4$, $\overline{X} = 1.500$ $R = .0428$ Action?

<u>Problem No. 3</u>

You are the OIC of a maintenance activity that includes a radio repair and calibration facility. You decide to establish a quality control system to determine if the frequency dial setting is exactly matched to the frequency being received. You know that due to the inherent nature of the equipment and the calibration process, the frequency dial setting and the frequency being

received will not be exactly matched but will be close. You decide on a system of units that measures the difference between the frequency dial setting and the actual frequency received (let's call them minicycles).

When you are convinced that the repair and calibration process is "in control," you take 3 samples of 6 radios in each sample and "measure" the difference between the frequency dial setting and the actual frequency received. You record these differences in minicycles as follows:

SAMPLE NO. 1	DIFFERENCE BETWEEN INDICATED AND ACTUAL FREQUENCY (MINICYCLES)
Radio 1	2.00
2	0.00
3	3.00
4	2.00
5	4.00
6	1.00
SAMPLE NO. 2	
1	4.00
2	1.00
3	2.00
4	0.00
5	1.00
6	2.00
SAMPLE NO. 3	
1	0.00
2	0.00
3	2.00
4	4.00
5	5.00
6	3.00

Set up the appropriate control chart or charts to monitor the quality of this process. Describe how you would use the chart or charts to monitor the process quality.

PROBLEM NO. 4

Refer to Problem 6 in Problem Set No. 2. Determine the control limits for the appropriate control charts to monitor this process (use ranges, not standard deviations).

APPENDIX 1

Factors For Computing Control Chart Lines

Number of Observations in Sample, n	Chart for Averages			Chart for Standard Deviations						Chart for Ranges						
	Factors for Control Limits			Factors for Central Line		Factors for Control Limits				Factors for Central Line		Factors for Control Limits				
	A	A_1	A_2	c_2	$1/c_2$	B_1	B_2	B_3	B_4	d_2	$1/d_2$	d_3	D_1	D_2	D_3	D_4
2	2.121	3.760	1.880	0.5642	1.7725	0	1.843	0	3.267	1.128	0.8865	0.853	0	3.686	0	3.267
3	1.732	2.394	1.023	0.7236	1.3820	0	1.858	0	2.568	1.693	0.5907	0.888	0	4.358	0	2.575
4	1.500	1.880	0.729	0.7979	1.2533	0	1.808	0	2.266	2.059	0.4857	0.880	0	4.698	0	2.282
5	1.342	1.596	0.577	0.8407	1.1894	0	1.756	0	2.089	2.326	0.4299	0.864	0	4.918	0	2.115
6	1.225	1.410	0.483	0.8686	1.1512	0.026	1.711	0.030	1.970	2.534	0.3946	0.848	0	5.078	0	2.004
7	1.134	1.277	0.419	0.8882	1.1259	0.105	1.672	0.118	1.882	2.704	0.3698	0.833	0.205	5.203	0.076	1.924
8	1.061	1.175	0.373	0.9027	1.1078	0.167	1.638	0.185	1.815	2.847	0.3512	0.820	0.387	5.307	0.136	1.864
9	1.000	1.094	0.337	0.9139	1.0942	0.219	1.609	0.239	1.761	2.970	0.3367	0.808	0.546	5.394	0.184	1.816
10	0.949	1.028	0.308	0.9227	1.0837	0.262	1.584	0.284	1.716	3.078	0.3249	0.797	0.687	5.469	0.223	1.777
11	0.905	0.973	0.285	0.9300	1.0753	0.299	1.561	0.321	1.679	3.173	0.3152	0.787	0.812	5.534	0.256	1.744
12	0.866	0.925	0.266	0.9359	1.0684	0.331	1.541	0.354	1.646	3.258	0.3069	0.778	0.924	5.592	0.284	1.716
13	0.832	0.884	0.249	0.9410	1.0627	0.359	1.523	0.382	1.618	3.336	0.2998	0.770	1.026	5.646	0.308	1.692
14	0.802	0.848	0.235	0.9453	1.0579	0.384	1.507	0.406	1.594	3.407	0.2935	0.762	1.121	5.693	0.329	1.671
15	0.775	0.816	0.223	0.9490	1.0537	0.406	1.492	0.428	1.572	3.472	0.2880	0.755	1.207	5.737	0.348	1.652
16	0.750	0.788	0.212	0.9523	1.0501	0.427	1.478	0.448	1.552	3.532	0.2831	0.749	1.285	5.779	0.364	1.636
17	0.728	0.762	0.203	0.9551	1.0470	0.445	1.465	0.466	1.534	3.588	0.2787	0.743	1.359	5.817	0.379	1.621
18	0.707	0.738	0.194	0.9576	1.0442	0.461	1.454	0.482	1.518	3.640	0.2747	0.738	1.426	5.854	0.392	1.608
19	0.688	0.717	0.187	0.9599	1.0418	0.477	1.443	0.497	1.503	3.689	0.2711	0.733	1.490	5.888	0.404	1.596
20	0.671	0.697	0.180	0.9619	1.0396	0.491	1.433	0.510	1.490	3.735	0.2677	0.729	1.548	5.922	0.414	1.586
21	0.655	0.679	0.173	0.9638	1.0376	0.504	1.424	0.523	1.477	3.778	0.2647	0.724	1.606	5.950	0.425	1.575
22	0.640	0.662	0.167	0.9655	1.0358	0.516	1.415	0.534	1.466	3.819	0.2618	0.720	1.659	5.979	0.434	1.566
23	0.626	0.647	0.162	0.9670	1.0342	0.527	1.407	0.545	1.455	3.858	0.2592	0.716	1.710	6.006	0.443	1.557
24	0.612	0.632	0.157	0.9684	1.0327	0.538	1.399	0.555	1.445	3.895	0.2567	0.712	1.759	6.031	0.452	1.548
25	0.600	0.619	0.153	0.9696	1.0313	0.548	1.392	0.565	1.435	3.931	0.2544	0.709	1.804	6.058	0.459	1.541
Over 25	$\frac{3}{\sqrt{n}}$	$\frac{3}{\sqrt{n}}$				*	**	*	**							

$*1 - \frac{3}{\sqrt{2n}}$ $\qquad **1 + \frac{3}{\sqrt{2n}}$

Reproduced from ASTM Manual on Quality Control of Materials, American Society for Testing Materials, Philadelphia, Pa., 1951.

CHAPTER 6

PROCESS CONTROL: CONTROL CHARTS FOR ATTRIBUTES: PROPORTION DEFECTIVE (P) CHART

On page 34 we discussed the type of quality characteristics that result in an item being classified as defective or non-defective. We pointed out that this is a Bernoulli process and that when several Bernoulli processes (trials or observations in a sample) are combined to form a sample size greater than one, the outcomes form a binomial distribution. We further pointed out that if the sample size is large enough, the binomial distribution can be approximated by the normal distribution.

Specifically, if we take k samples of size n, the population mean of the distribution is Π, and the variance is given by:

$$\sqrt{\frac{\Pi(1-\Pi)}{n}}$$

We estimate Π by $\bar{p}$, and can establish limits for a proportion defective (p chart) as follows:

$$\bar{p} \pm 3\sqrt{\frac{\bar{p}\ (1-\bar{p})}{n}}$$

Example

Refer to the example problem on page 39. Determine the UCL and LCL for a Proportion Defective Control Chart (p chart).

$k = 10 \qquad n = 50$

$\bar{p} = .12$

$$UCL = \bar{p} + 3\sqrt{\frac{(.12)(.88)}{50}}$$

$$= .12 + .1378 = .2578$$

$$LCL = \bar{p} - 3\sqrt{\frac{(.12)(.88)}{50}}$$

$$= .12 - .1378 = -.0178$$

Since $\bar{p}$ cannot be less than 0, LCL = 0

We can leave the control chart limits in terms of the fraction defective or we can multiply the fraction defective limits by the sample size and establish the limits in terms of the number of defectives in the sample.

$$(UCL)n = .2578(50) = 12.89 \cong 13$$

$$(LCL)n = 0(50) = 0$$

Control Chart

UCL = .2578 or 12.89 ≈ 13 defectives out of a sample of 50

LCL = 0

1 2 3 4 5 Sample No.

Problem Set No. 5

Problem No. 1

The Air Force does not use "verifiers" on its key punch operations; therefore, errors can be expected to occur in these operations. You have a highly motivated, well trained set of operators who appear to be making the minimum

number of errors possible when key punching supply requisitions. Over a period of several days, you take 5 samples of 100 requisitions per sample and check them thoroughly for errors. Your results are as follows:

SAMPLE NO.	NUMBER OF INCORRECT REQUISITIONS IN SAMPLE
1	9
2	6
3	7
4	10
5	8

Set up and sketch an appropriate control chart (with limits) to monitor this "process" in the future and describe how you might use it.

You decide to monitor the quality on a frequent basis, and for several weeks all samples indicate that the process is "in control." Then you take a series of samples with the following results:

SAMPLE NO. (n = 100)	NUMBER OF INCORRECT REQUISITIONS IN SAMPLE
39	20

Plot this data point on your sketch. What action would you take, if any?

SAMPLE NO.	NUMBER OF INCORRECT REQUISITIONS IN SAMPLE
45	14

Plot this data point on your sketch. What action would you take, if any?

Problem No. 2

One of the ALC's producing repaired aircraft engines decided to set up an appropriate control chart to determine if the number of defective engines produced was excessive. For 30 consecutive days, they inspected 50 engines each day to determine the number of defective engines. Every effort was made during this 30-day period to insure that the process was "in control." The following data were collected:

DAY	NUMBER OF DEFECTIVE ENGINES
1	1
2	0
3	1
4	4
5	1
6	5
7	2
8	1
9	3
10	3
11	3
12	7
13	3
14	2
15	2
16	3
17	0
18	3
19	3
20	2
21	4
22	3
23	1
24	2
25	3
26	0
27	2
28	5
29	2
30	1
TOTAL 30	72

a. Determine the appropriate control chart(s) and their centerline(s) and limits.

b. Discuss how this chart should be used in the future. Give examples of the type of data that might be collected and what action you would take.

CHAPTER 7

PROCESS CONTROL: CONTROL CHARTS FOR ATTRIBUTES: DEFECTS PER UNIT (C) CHART

On page 36 we discussed the type of quality characteristics that result in an item being classified by the "number of defects" the item possesses. We pointed out that the number of defects per unit usually follows a Poisson distribution. We further pointed out that the parameter of the Poisson distribution can be estimated by $\bar{c}$, the average number of defects found in k units.

We can establish control charts for defects per unit (c charts) as follows:

The mean and variance of a Poisson distribution are both λ; therefore, the standard deviation is $\sqrt{\lambda}$.

The control chart limits are, therefore:

$\lambda \pm 3\sqrt{\lambda}$

and these are estimated from k units by

$c \pm 3\sqrt{\bar{c}}$

Example

Refer to the example problem on page 41. Determine the UCL and LCL for a Defects per Unit Control Chart (c chart).

$$k = 20 \qquad \bar{c} = 1.75$$

$$UCL = \bar{c} + 3\sqrt{\bar{c}} = 1.75 + 3\sqrt{1.75} = 5.72$$

$$LCL = \bar{c} - 3\sqrt{\bar{c}} = 1.75 - 3\sqrt{1.75} = -2.2186$$

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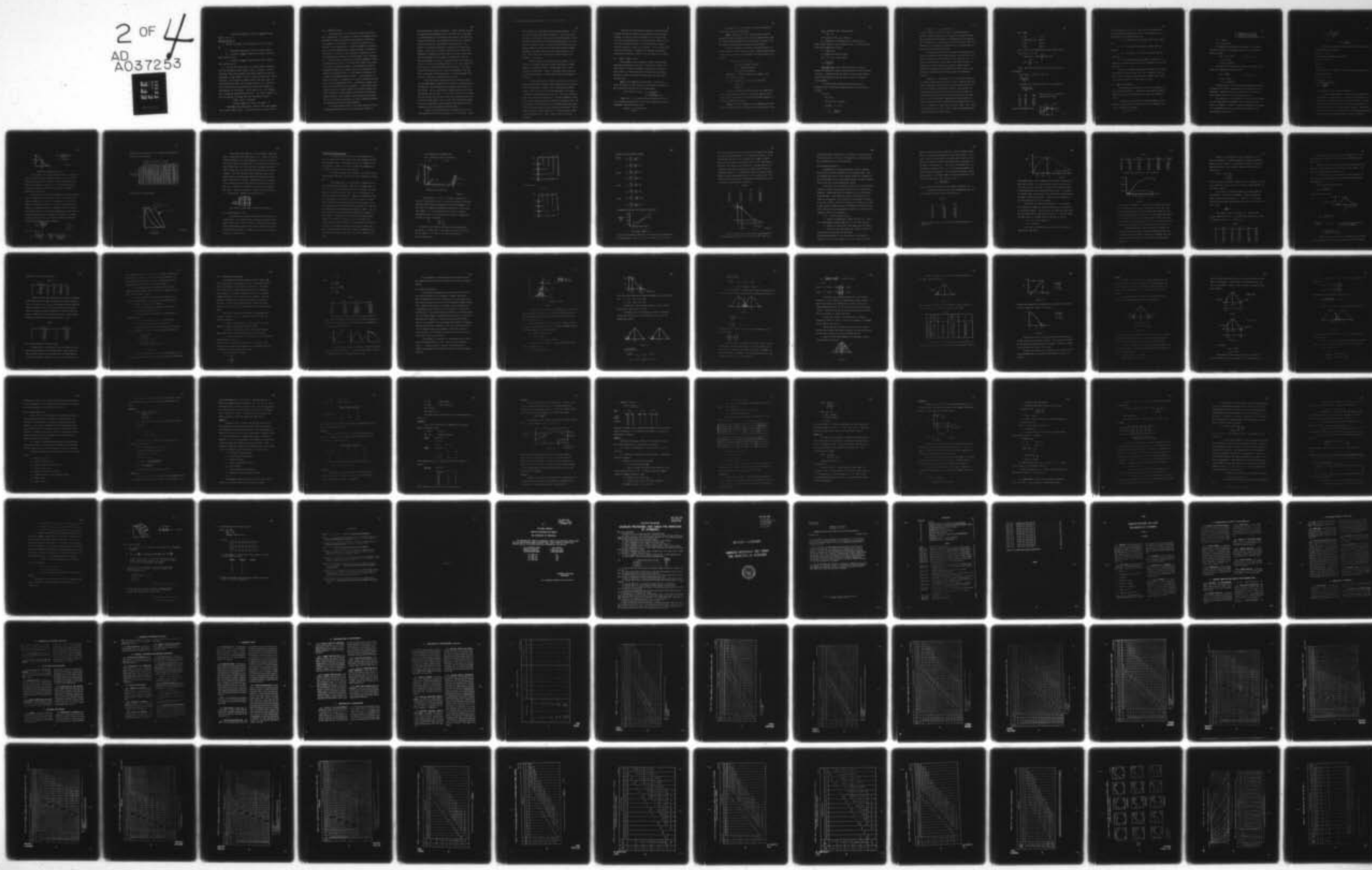


Since the number of defects <u>cannot</u> be less than 0, LCL = 0.

<u>Problem Set No. 6</u>

1. Refer to problem 5 of Problem Set No. 2 on page 45.

a. Determine appropriate control chart limits.

b. A wing was <u>later</u> inspected and had 11 defects. What would you do?

c. A wing was <u>later</u> inspected and had 6 defects. What would you do?

2. You are the supervisor of a large pool of administrative personnel whose primary task is typing. You are satisfied that the personnel are highly motivated and are producing at the highest level of effectiveness that can be expected. You decide to capture data from this state of effectiveness so that you can keep track of the effectiveness and detect any statistically significant change in performance in the future. You decide to use as a sample unit a page of typewritten material. You take a sample of 100 full pages of typing with the following results:

Sample size: 100 pages

Average number of errors per page: 4

Determine the appropriate control chart and compute the control chart limits. Label the units of your limits.

VIII. SAMPLING OVERVIEW

A broad definition of quality would include its creation and its measurement. The creation of quality is a function of many parameters and would be affected by the processes, the materials, the equipment, and the workers. To begin with, quality can be different for the same product. A quality sailboat to the weekend sailor is surely different than a quality sailboat to an America's Cup skipper. So quality is what we define as "quality" and this will depend upon the function of the end product, costs, equipment, etc. Once this quality is defined one must then determine a method of measuring this "quality." One method often used in this measuring process is acceptance sampling. Using accepted statistical procedures-estimates of the product quality are computed and then compared to acceptable limits. On the surface this appears to be a rather simple straightforward approach: 1) define quality, 2) sample the product, 3) determine if the quality standards have been met, and 4) take appropriate action. Unfortunately, however, few things are as simple as they first appear. In the following pages we will discuss in a logical sequence the thinking and basic concepts that quality control managers would follow in establishing sampling systems. Many government developed plans are available and will be included to demonstrate the ease of selecting appropriate sampling plans using Military Standards.

From your carpeted office on the second floor of the wing headquarters building you are able to manage your smooth and

efficient mission oriented organization. Mission aircraft take off on schedule, your reenlistment rate is high--you run a "good ship." In comes Miss Miller, your secretary; she brings in the letter you dictated this morning. She has been with you since you arrived on station two years ago and her work is always excellent. She returns to her desk and you begin to proofread the letter before signing. As you read, you project yourself into the shoes of the addressee to determine if what you wish to say does in fact convey the correct thoughts to the reader. No problem here, you can really communicate. But mercy, a misspelled word, an obvious typing error. Now you must decide whether or not to sign, correct the error in pen, or have Miss Miller retype the letter. You start thinking--who does this go to? What is the suspense? Will this error or retyping irritate Miss Miller? Will the addressee notice the error? What will he think of you if he does?

Well, you decide to ask Miss Miller to retype the letter. You have established a standard for the letter--no misspelling will be permitted. This standard is the acceptable quality level for this letter. You will proofread the retyped product and if within the standard, you will sign. In a talk with Miss Miller you advise her that you will not sign any letters with misspellings--you have a quality control system. Now it is not very complicated or fancy but it will assure with a high probability that letters with misspellings will not be dispatched from your office.

The hot line rings and the Wing Commander says "Joe, I'm concerned about the military appearance of our people here. Check

this out and let me know what you think by 0900 tomorrow." "Will do, sir," you reply just before he hangs up. It's a busy day but you better get an answer to this one and by 0900 tomorrow. How do you start? Obviously you can't checkout every person on the base, but you could get a sample. You decide to look at haircuts, shoe shines, shaves, and variations from AFM 35-10 concerning uniform standards. You figure that by visiting several offices, a few shops, and the BX a good cross section of the military can be observed. So off you go.

The next morning at the 0900 meeting you report, "Sir, I observed 121 military yesterday afternoon and noticed 24 needed haircuts, 5 needed shoe shines, 3 needed shaves, and 8 were in violation of AFM 35-10." "Just as I suspected, these young guys just won't get haircuts. We will have to place more emphasis on haircuts."

On your way back to your office it occurs to you that your sampling and the Wing Commander's belief that 24 out of 121 was too many long hairs,was, in effect, a use of sampling to determine quality. And that his plan to do something about the situation constitutes a crude quality control system. But as you think more about the situation the worse it gets. The Wing Commander assumed that the hair violators were young and that they were all men. Was your sample truly representative of the entire base military population? Were the number of other violations satisfactory? What if there were only 3 haircut violations? You have a quality control plan but how good is it? Does it matter to you or the Wing Commander?

These are just two examples of quality controlling and by no means are either the best or only possible way to solve these problems. One thing is obvious, however, for in the first case each letter is proofread while in the second case a sample is used to reflect the base population. As with determining courses of action,one potential course is to do nothing. In the sections that follow we will develop a methodology for determining whether to 100% inspect (screening), sample, or do not inspect at all (waive).

IX. SCREEN - SAMPLE - WAIVE

When managers decide to measure a quality which has been previously determined,the next step in the decision process is to select either a screening, sampling, or waiving (no inspection) plan of action. A mathematical model follows which will assist managers in making intelligent decisions based upon known and/or estimated data.

<u>WAIVE</u> If no inspection of the product is selected as a course of action, the total costs will vary linearly with the number of defectives and the cost of each replacement.

Total Cost/Lot = $P'NC_R$

P' = % Defective
N = Lot Size
C_R = Replacement Cost

Example No. 1 In our work we know from experience that 1% of our products are defective, our lot size is 1000 units, and the replacement costs are \$5.00 per unit.

$$TC_W/Lot = \$(.01)(1000)(5.00)$$
$$= \$50.00$$

This means that on the average our costs for defectives will be \$50.00 per lot of 1000 units.

SCREEN Screening is a 100% inspection plan and may be required of certain operations. Will you sign letters without reading, send a man to the moon without checking his life support system, drive to Chicago without looking at your gas gauge?

There are times when a screening of the final product is essential and this can be based upon safety, mission accomplishment, or the cost of a defective in the system. The screen costs per lot will be

$$T.C._{SC}/Lot = NC_T + K_1 P'NC_R$$

C_T = Cost to Inspect one unit

K_1 = % Defectives Missed

N, P', C_R Same as Example 1.

Example No. 2 Using the same data as example 1 plus

$C_T = \$.20,\ K_1 = .005$

$$T.C./Lot = (1000)(.20) + (.005)(.01)(1000)(5.00)$$
$$= 200 + .25$$
$$= \$200.25$$

Even in a screening plan defectives will be missed since either your equipment is faulty or the operator makes an error. This K_1 factor is difficult to determine but either experience or an accuracy check can be used.

SAMPLE The costs of sampling are a combination of acceptance (accepting the lot) and rejection (rejecting the lot) costs.

TC_{SM} = Acceptance Cost + Rejection Cost

= AC + RC

$AC = P_a[nC_T + (N-n)_{P'} \, C_R + nk_2P'C_R]$

P_a = Probability of accepting the lot based upon the known fraction defective and the sampling plan. (In later sections this will be explained in detail.)

n = sample size

K_2 = defectives missed in sample

C_T, N, P', & C_R - same as above

$$RC = \frac{nC_T(1-P_a)}{P_a}$$

Crossover Points Given the three options the quality manager can determine a specific optimum program for each particular situation. Crossover points are defined as that percent defective level at which switching from one plan to another is judged the most economical.

If for some reason sampling has been eliminated as a possible course of action, then either screening or waiving must be selected.

If we set

$TC_W = TC_{SC}$

$P_X' \, NC_R = NC_T + K_1P_X'NC_R$

$P_X'(C_R)(1 - K_1) = C_T$

$$P_X' = \frac{C_T}{C_R(1-K_1)}$$

and when $P' > P_X'$ screen the lot.

However, often we can reduce the costs of checking quality by sampling. Equating TC_{SC} and TC_W to TC_{SM} will not provide reliable decision-making information due to the variability of the probability of acceptance as a function of lot quality in percent defectives. Therefore, it is necessary to graphically plot all three curves in order to locate the crossover points.

The weakness in this particular approach is based upon the initial reliability of the entering arguments, the quantity of calculations required and the variability of the data over time. In addition, those who will actually operate the quality system, the inspectors, may not be qualified to compute crossover points. Therefore we recommend that the managers of quality control plans provide the operators with guidelines rather than complicated equations.

Example No. 3 The managers of a quality control system in an aircraft electronics parts supplier wishes to provide guidelines for his inspectors concerning the waive/sample/screen decision on one of his products, say transistor diodes. Over the past four years he has produced over one million diodes and estimates the percent defective to be 4% in lots of 500 parts each. Utilizing MIL STD 105 he has selected a sampling plan that consists of a sample of size 50 and has a probability of acceptance of 86% for 1 lot at 4% defective. The K_1 and K_2 are equal 0.005. The C_R value is \$5.00 and the C_T is \$.18. (Note: Selection of sampling plans using MIL STDs will be covered later.)

$TC_W = P'NC_R$

$= (.03) \qquad\qquad\qquad\qquad \$\ 75.00$

$= (.04)(500)(5.00) = \$100.00$

$= (.05) \qquad\qquad\qquad\qquad \$125.00$

$= (.06) \qquad\qquad\qquad\qquad \$150.00$

Note: N and C_R are constants TC_W varies linearly with P'.

$$TC_{SC} = NC_T + K_1\ P'\ NC_R$$

$$= (500)(.18) + (.005)\begin{pmatrix} .03 \\ .04 \\ .05 \\ .06 \end{pmatrix}(500)(5.00)$$

$$= 90 + \begin{matrix} .375 \\ .50 \\ .625 \\ .75 \end{matrix} \cong 90$$

Note: The relative values of first and second terms in the equation.

$$TC_{SM} = P_a[nC_T + (N-n)P'C_R + nK_2P\ C_R] + \frac{n\ C_T(k-P_a)}{P_a}$$

$$= P_a[(50)(.18) + (500-50)(P')(5.00) + 50\ (.005)(P')(5)] + \frac{50(.18)(1-P_a)}{P_a}$$

P'	P_a*	TC_{SM}
.02	.99	53.6
.03	.95	72.7
.04	.86	86.7
.05	.77	96.3
.06	.65	98.4

*With P' given P_a is found from appropriate OC curve.

From this information plot

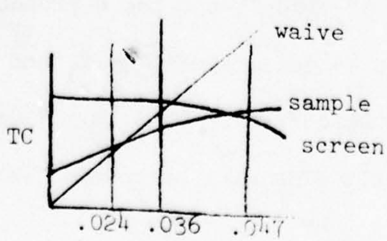


Figure 1

Given the results of Figure 1 we merely select the minimum cost approach based upon the predicted percent defectives in the lots. Our guidance to the inspectors would be:

1. If P' is expected to be less than .024, use no inspection.

2. If P' is expected to be between .024 and .047, use sampling.

3. If P' is expected to be greater than .047, use 100% inspection.

4. If for some reason sampling cannot be used and P' is expected to be greater than .036, use 100% inspection, if less than .036 waive.

One must be extremely cautious when deciding not to inspect even though the economics does favor such an approach. The more prudent quality control planner would use a reduced sampling plan (to be explained later) or a spot-check procedure.

X. SAMPLING FUNDAMENTALS

A sampling plan consists of a lot size N, a sample size n, and an acceptance number C. This section will quickly review the applicable statistical distributions and their use in sampling theory.

The Bernoulli distribution is appropriate when only two mutually exclusive outcomes are possible and the probability of these outcomes remain constant.

$$f(X) = P^X q^{1-X}$$

P = probability of success
q = probability of failure
X = random variable and equal 1 or 0.

$\mu = P$ (mean)

$\sigma^2 = Pq$ (variance)

The binomial is derived from the Bernoulli. The random variable X is equal to the number of successes in n independent Bernoulli trials.

$$f(X) = \binom{n}{X} P^X q^{n-X} \qquad X = 0,1,2,\ldots,n$$

$\mu = nP$ (mean)

$\sigma^2 = nPq$ (variance)

The Poisson distribution also describes the number of successes of n independent Bernoulli trials.

$$f(X) = \frac{e^{-\mu}\mu^X}{X!} \qquad X = 0,1,2,\ldots,n$$

$\mu = nP$ (mean)

$\sigma^2 = nP$ (variance)

Both the Binomial and the Poisson distributions are useful in sampling from infinite populations or finite populations with replacement. Remember, though, the probability of success must remain constant from trial to trial in both cases.

When replacement is not possible, for one reason or another, then the hypergeometric distribution is more appropriate than either the Binomial or Poisson. The exact probability of successes in n independent Bernoulli trials without replacement is the hypergeometric distribution

$$f(X) = \frac{\binom{NP}{X} \cdot \binom{Nq}{n-X}}{\binom{N}{n}}$$

$$\mu = nP$$

$$\sigma^2 = (nPq)\left(\frac{N-n}{N-1}\right)$$

Below are some rules of thumb that may be used in estimating the hypergeometric distribution.

Rule 1: If $\frac{n}{N} < 0.1$

use Binomial distribution as estimator.

Rule 2: If $\frac{n}{N} < 0.1$

and $P < 0.1$

and $n > 16$

use the Poisson. To estimate the binomial with the normal distribution follow rule 3.

Rule 3: If $N > 30$

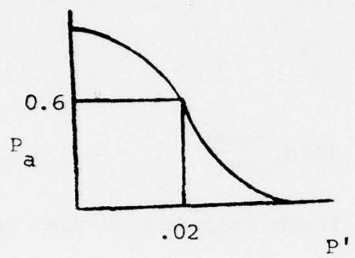
and P and $q > 0.1$

or if $np \geq 5$ and $n(1-P) \geq 5$

use $Z = \frac{X - Np}{\sqrt{Npq}}$

as an estimator of the binomial distribution.

Operating characteristic curves are used to determine the effectiveness of sampling plans. In sampling, the objective is to accept good lots and reject bad (or poor quality) ones. Unfortunately when using sampling plans there exists the possibility of either rejecting a good lot or accepting a bad one. These probabilities can easily be evaluated by use of the operating characteristic (OC) curve of different sampling plans, see Figure 2.



P_a = Probability of Acceptance

P' = % Defective

Figure 2

Operating Characteristic Curve

As an example let us look at several plans. To keep this simple we want to compare different plans for a lot of 10 items with sample sizes from one to three. That is from a lot of 10 items we will select at random 1, 2, or 3 items and base our decision to accept or reject the lot based upon the number of defectives in the sample.

First we must calculate the probability of finding a defective in a sample of size n from a lot of size 10 based upon the number of defectives in the lot. For example if n = 3 and the number of defectives in the lot is 0, then the probability of a defective in the sample will be 0. However, if the lot contains one defective there is a 70% and 30% probability that zero and one defective respectively will be found in our sample. Our example is sampling from a finite (10) population without replacement. You said hypergeometric--right? Remember

$$f(X) = \frac{\binom{NP}{X}\binom{Nq}{n-X}}{\binom{N}{n}} \qquad \begin{array}{l} N = 10 \\ n = 3 \\ X = 1 \\ P = 0.1 \end{array}$$

Let $NP = (10)(.1) = 1$

$$P_a = \frac{\binom{N-NP}{n-x}\binom{NP}{x}}{\binom{N}{n}} = \frac{\binom{9}{2}\binom{1}{1}}{\binom{10}{3}} = \frac{\left(\frac{9!}{2!7!}\right)\left(\frac{1!}{1!0!}\right)}{\left(\frac{10!}{3!\ 7!}\right)} = .30$$

Similarly we can compute all to the relevant data which would result in the table below:

Number of Defectives in Sample

		A	B	C	D	E	F
		0	1	2	3	0 or 1	0,1,or 2
Defectives in Lot	0	100	-	-	-	100	100
	1	70	30	-	-	100	100
	2	46.7	46.7	6.6	-	93.4	100
	3	29.2	52.5	17.5	0.8	81.7	99.2
	4	16.7	50.0	30	3.3	66.7	96.7
	5	8.3	41.7	41.7	8.3	50.0	91.7
	6	3.3	30	50	16.7	33.3	83.3
	7	0.8	17.5	52.5	29.2	18.3	60.8
	8	0	6.6	46.7	46.7	6.6	53.3
	9	0	0	30	70	0	30
	10	0	0	0	100	0	0

Next we plot the above values.

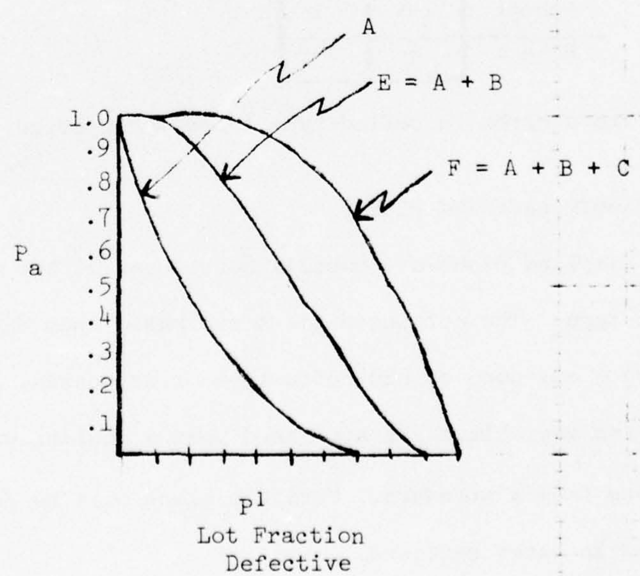


Figure 3

Now we have three plans (A, E, F) to evaluate. Note that plan A is more restrictive than either E or F. That is if the lot fraction defective is 0.2 (two defectives in the lot of 10) then plan A will result in accepting 46.7% of the time, plan E 93.4%, and plan F 100% of the time. More lots will be accepted using plan F than the other two, thus this plan has the greatest risk for the consumer. Also note that plan A will reject many lots of fair quality (say 3 to 5 defectives), whereas the other plans reject fewer at this level of quality. Interesting to note is the fact that all three plans will accept very good lots and reject very poor ones. Therefore the selection of the proper plan must be based upon a compromise between the consumer and producer risks, α & β respectively. Remember from your statistics

	Lot Quality	
	Good	Bad
Accept	$1-\alpha$	β
Reject	α	$1-\beta$

The α error is called type I and the β error type II.

XI. ATTRIBUTE SAMPLING PLANS

Sampling plans are usually considered either attribute or variable type. The attribute plans are based upon discrete categories such as; good or bad, effective or defective, pass or fail. Whereas the variable plans are based upon a continuous scale and deviations from a standard. Variable plans will be developed and explained in later sections.

Specified α, β, AQL, and LTPD

In designing or selecting an optimum sampling plan one must be concerned with exactly what results are desirable and what are acceptable risks. Previously we defined the consumer (β) and the producer (α) risks. In addition to these two parameters we must next identify "good" and "bad" quality.

But before we begin our development, let's look at these four parameters that will eventually be used to develop our optimum plan.

The consumer risk, β, is well known to those with only a minimum statistical background. Seems like β is always equal to 10 or 5%, at least this is what we find in most tables. But what does a 5% consumer risk mean? Well, this is the percent of the time that we can accept a bad lot. Similarly the producer's risk, α, is the percent of the time we can reject a good lot. Seems rather simple. But who determines good and bad criteria? Let's say good quality is labeled the acceptable quality level (AQL) and poor quality the lot tolerance percent defective (LTPD). The consumer determines all four parameters--remember the customer is always right. The problem is in determining the proper values. However, for the sake of argument let us assume that we can scientifically do this and press on. Now combining α and the AQL in effect we are saying that we will be willing to reject good quality (AQL) α percent of the time. Similarly combining β and LTPD means that we will accept a bad lot (LTPD) β percent of the time.

As an example let us assume that:

AQL = 1% Defective LTPD = 6% Defective

α = 5% β = 10%

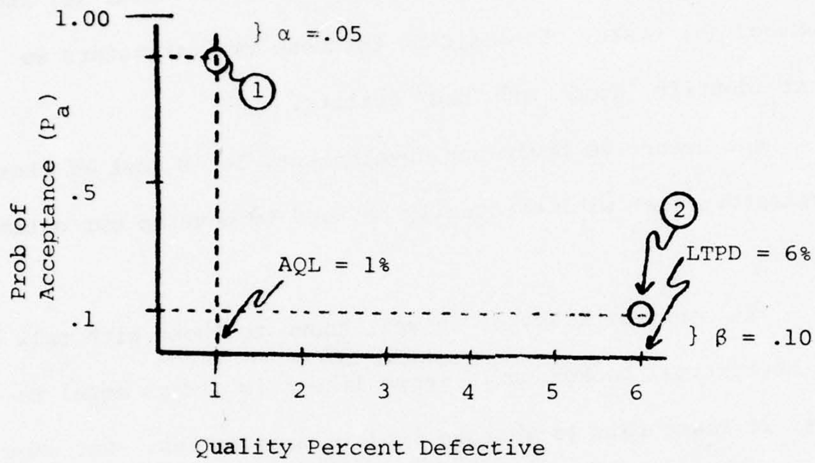


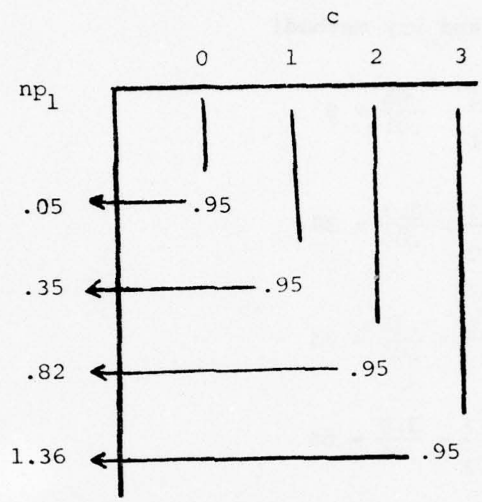
Figure 4

Points labeled 1 and 2 in Figure 4 represent two points of our desired OC curve. If our plan satisfies our selected parameters then we have an optimum plan for these parameters. Our next task is to compute the appropriate sample size (n) and acceptance number (c). Let us assume that we can use the Poisson approximation and a cut and try method of solution. Remember the criteria for using the Poisson?

Let AQL = p_1

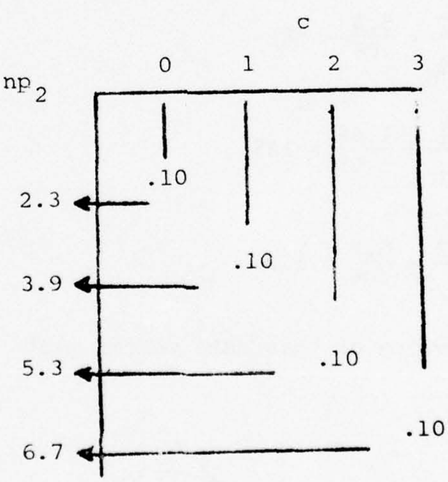
LTPD = p_2

We know the n and c must be selected so as to satisfy both np_1 and np_2. To begin with in this example if we let c = 0,1,2,3, and then with $1 - \alpha = 0.95$ we can enter the cumulative Poisson tables thusly:



Similarly with

$\beta = 0.10$



Now on to the cut and try method!

c = 0

$$n_\alpha = \frac{np_1}{p_1} = \frac{.05}{.01} = 5$$

$$n_\beta = \frac{np_2}{p_2} = \frac{2.3}{.06} = 38$$

c = 1

$$n_\alpha = \frac{np_1}{p_1} = \frac{.35}{.01} = 35$$

$$n_\beta = \frac{np_2}{p_2} = \frac{3.9}{.06} = 65$$

c = 2

$$n_\alpha = \frac{np_1}{p_1} = \frac{.82}{.01} = 82$$

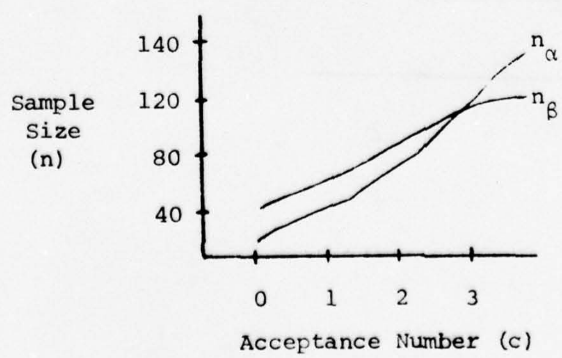
$$n_\beta = \frac{np_2}{p_2} = \frac{5.3}{.06} = 88$$

c = 3

$$n_\alpha = \frac{np_1}{p_1} = \frac{1.45}{.01} = 145$$

$$n_\beta = \frac{np_2}{p_2} = \frac{6.7}{.06} = 112$$

To understand the value of this data we can plot



Note that an acceptance number does not exist that will satisfy our criteria exactly. However, an acceptance number of 2 with sample

sizes of 82 and 88 are close. But since we can have but one sample size we can do several things: a) use either 82 or 88 for n, b) use the average value of 85, or c) use some value between 82 and 88 based upon the relative importance of points 1 and 2 (see Figure 5.) Generally, the average value is selected. If we follow this convention our plan will then consist of a sample size of 85 and an acceptance number of 2. Obviously this 85/2 plan does not exactly meet our original specifications, but it will be very close. Now we must select enough points to adequately construct the OC curve and check our specifications versus plan.

TABLE 1

n	p'	np'	P_a
85	.01	.85	.945
85	.02	1.7	.757
85	.04	3.4	.340
85	.06	5.1	.117
85	.08	6.8	.034
85	.10	8.5	.009

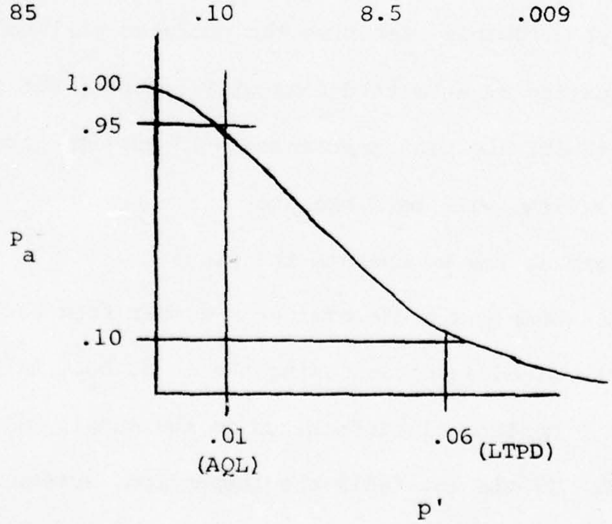


Figure 5

As will be noted the OC curve does not pass through the specified points at AQL or LTPD but is very close. Now if we

decided that either the AQL and α or the LTPD and β must be met by our plan, then use n = 82 or n = 88 respectively. Fixing one point will increase the error at the other point.

XII. RECTIFYING INSPECTION

Sometimes it is economically prudent to have a sampling plan that will control the quality of the outgoing product. That is, determine the quality of the outgoing product as a function of the incoming quality and in the process determine the worst possible quality that will be passed through the system.

This type of plan is generally referred to as the rectifying inspection and the average outgoing quality (AOQ) is the principle parameter. These plans consist of sampling each lot and screening those that fail. Think about this one--if rejected lots are returned to the producer, is the quality of the accepted lot altered in any way? Probably over time the producer will improve his output and the quality of submitted lots will improve, but this will take time. With our AOQ plan, improvements in quality, at least from the consumer's view, will be immediate.

Here is how we operate the plan:

A. Sample a predetermined n number from each lot. This n can be determined as before using the α, β, AQL, LTPD criteria.

B. Replace all defectives in the sample with good items.

C. If the lot fails the inspection, screen the entire lot and replace all defectives with good items.

With the above procedure let us now investigate our expected results. If the lot size equals N, then (N-n) items will not be

checked if the sample passes inspection. And if the percent defective is p' then the unchecked portion will contain $(N-n)p'$ defectives. From our previous work we know that with a given plan (n&c) that the OC curve will reflect the probability of acceptance as a function of lot quality, p'. From this we can conclude that on an average we can expect to have $P_a\ p'\ (N-n)$ defectives remaining in the lot after each inspection. We now define the average outgoing quality (AOQ) as the average number of defectives remaining in the lot after inspection divided by the lot size. Or

$$AOQ = \frac{P_a p'\ (N-n)}{N} \ .$$

When N is much larger than n we can estimate AOQ by $AOQ = P_a\ p'$.

For ease of calculation let us use the sampling plan, n=85 and c=2, that we derived earlier and look at AOQ.

Table 2

p'	P_a	$P_a\ p'$
0	1.00	0
.01	.045	.009
.02	.757	.015
.03	.531	.016
.04	.34	.014
.08	.034	.003
.10	.009	.001

Using the data in Table 1 we can plot AOQ versus incoming lot quality, p'.

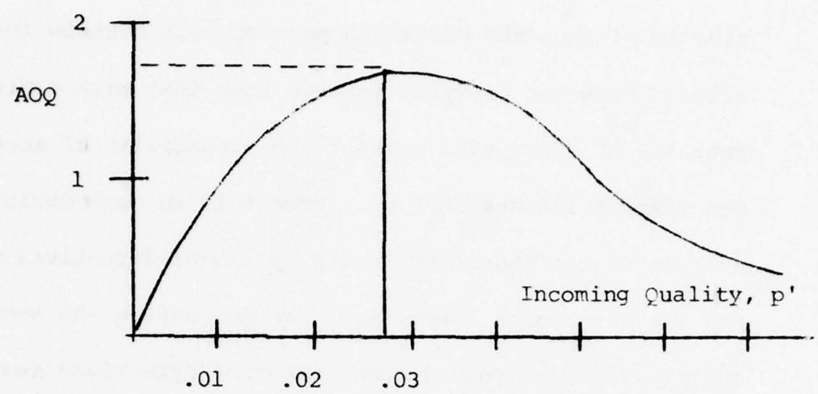


Figure 6

The maximum value in AOQ is referred to as the AOQL or average outgoing quality limit. Note that for both very poor and very good lots that the AOQ is very good. Naturally if the quality is high on the incoming that the outgoing will also be good. If incoming is extremely poor, the majority of the lots will be screened--again resulting in high quality output. Think of several examples of when this type plan would be very useful.

Inspections cost money and management will often require that estimates of inspection costs be made prior to the inspection of any quality program. Even if you are not asked, you should know how many items will be inspected on an average. If we first sample and then screen all rejected lots, we can expect to inspect

$$I = n + (N-n)\ \text{Prob (Rejection)}$$

$$= n + (N-n)(1-P_a)$$

Let's use our original 85/2 plan for lots of size 1000 & 5000 and plot our results.

Table 3

p'	P_a	$(1-P_a)$	I_{1000}	I_{5000}	$I_{10,000}$
0	1.00	0	85	85	85
.01	.945	.055	135	355	630
.02	.757	.243	307	1279	2494
.03	.531	.469	514	2390	4735
.04	.340	.660	689	3329	6629
.08	.034	.966	969	4833	9663

These results when plotted are in Figure 6.

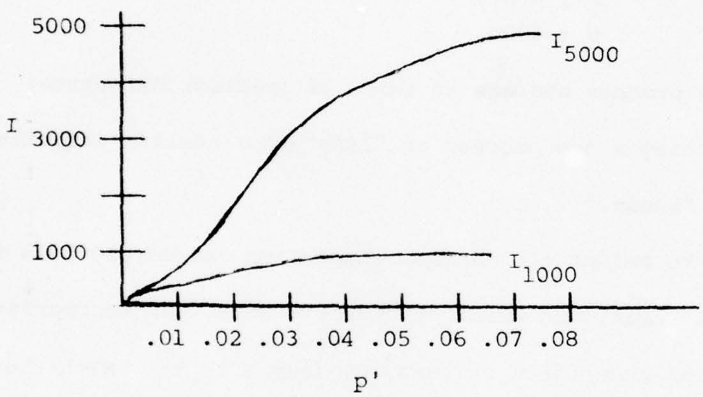


Figure 7

Note that for good quality lots the average inspections for lots of size 1000 are not 5 times as great as for lots of size 5000. But as the quality gets very poor whether 1000 or 5000 size lots are selected makes little difference. In other words when quality is high, larger lots reduce total inspections. There may be some true savings here. Why should you be limited to "small" lot sizes and be unable to profit by the "economy of scale" of big lots?

The above procedure enables the analyst to select from different lot sizes the best or minimum inspection strategy but does not define the optimum strategy from all possible lot sizes. A trial and error approach will be required to optimize this decision.

However, on the other hand if one is committed to a lot size for one reason or another procedures for determining minimum sample size are available. If one wishes to design a plan with a specified LTPD and β that minimizes inspections, follow the procedures below:

Given: LTDP = 0.05
β = 0.10
p'= 0.01*
N = 4000

*This is the process average in terms of fraction defective. Unless one is beginning a new process or "line" this average defective per lot will be "known."

Now to select the minimum inspection one merely uses the old faithful trial and error procedure. Select an appropriate range of trial acceptance numbers, c, (say 0 to 7). With these values use the Poisson tables and the given value of β to find the np'. Then

$$\frac{np'}{LTPD} = n$$

Next figure p'n or .01n in this case. Again use the Poisson tables and find P_a. And finally the average total number of inspections will be $I = n+(N-n)(1-P_a)$.

Table 4

c	np'	n	.01n	P_a	I
0	2.3	46	.46	.63	1509
1	3.9	78	.78	.82	784
2	5.3	106	1.06	.91	456
3	6.7	134	1.34	.95	327
4	8.0	160	1.60	.98	237
5	9.3	186	1.86	.988	232
6	10.5	210	2.10	.994	233
7	11.8	236	2.36	.997	247

We see from Table 4 that a plan with a sample size of 186 and an acceptance number of five will minimize the average inspections at 232.

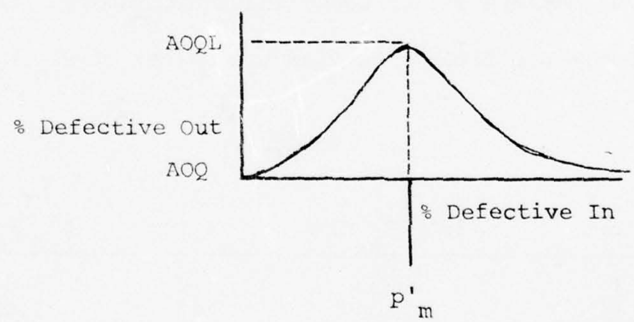
Should one be fortunate enough to be able to select the LTPD equal to 0.10 then the Dodge and Romig Tables could be used. Note the LTPD in these charts is labeled the p_t.

If the total number of inspections is to be minimized and the average outgoing quality level is known, follow the procedure outlined below:

From previous work we know that

$$AOQ = \frac{p' \, P_a \, (N-n)}{N}$$

and if we select the AOQL



$$AOQL = \frac{p'_m \, P_a \, (N-n)}{N}$$

$$\frac{(AOQL)\,Nn}{N-n} = (p'_m \, P_a \, n)^*$$

*See Dodge and Romig tables for this value or Table 6.

$$n = \frac{(p'_m \, P_a \, n)\, N}{N(AOQL) + (p'_m \, P_a \, n)}$$

Again we must use a trial and error approach. For example, Table 3 shows the calculations for a 4000 item lot with incoming

quality at 0.01 and an AOQL of 0.02.

Table 5

c	Y (p'_m P_a n)	n	p'	P_a	I
0	.3679	18	.01	.836	671
1	.8408	42	.01	.933	307
2	1.372	67	.01	.969	189
3	1.946	95	.01	.984	157
4	2.544	123	.01	.991	158

Table 5 reflects that a sample size of 95 and an acceptance number of three will minimize the average total number of inspections. Not only can the (P'_m P_a n) be obtained from the Dodge and Romig Tables but so also can the minimum total inspection plan. Should one deal with sampling plans often it would be prudent to obtain a complete set of Dodge and Romig Tables. Should these be unavailable use Table 6 to find the values of P'_m P_a n.

Table 6

c	Y (p'_m P_a n)	c	Y (p'_m P_a n)
0	.3679	6	3.812
1	.8408	7	4.472
2	1.371	8	5.146
3	1.942	9	5.831
4	2.544	10	6.528
5	3.168	11	7.233

XIII. DOUBLE AND MULTIPLE SAMPLING PLANS

Shortly after the discovery of the single sampling plans, the double and multiple plans were developed. These plans have two particular and distinct advantages over the single sampling plans. First and most important from an economic viewpoint, the

double sampling plan will reduce the total number of inspections required for the same protection. Naturally the multiple plans reduce the total inspections even more. Secondly, there is the psychological lift to giving a lot a second chance.

Let us discuss the general procedures for the double sampling plan and remember that the multiple is just more of the same. The procedures follow:

A. Select a sampling plan with two acceptance (a_1, a_2) and two rejection numbers (r_1, r_2) and two sample sizes (n_1, n_2).

B. Select a sample (n_1) and inspect.

C. If a_1 or less defectives observed, accept the lot.

D. If r_1 or more, reject the lot.

E. If more than a_1 but less than r_1 defectives, take a second sample, n_2.

F. If a_2 or less defectives total, accept the lot.

G. If r_2 or more defectives, reject the lot.

It must be noted that for double sampling, r_2 will equal $c_2 + 1$. Graphically our model could be depicted as in Figure 8.

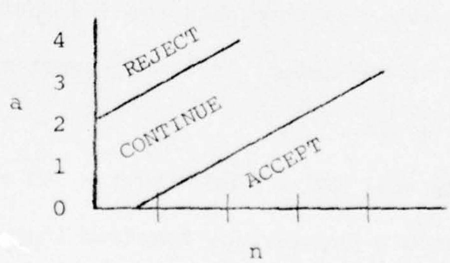


Figure 8

In later sections the MIL STD 105 will be explained and in this section actually double and multiple plans will be demonstrated.

XIV. CONTINUOUS SAMPLING PLANS

The previous work depicts sampling plans for those items that can easily be grouped together as lots. Unfortunately not all items are produced or are easily fitted into lots. Often times the variability of processes changes with time or the number of units produced. The assembly, production lines, or any conveyor transported material may not lend itself to grouping. For these and other reasons several excellent continuous plans have been developed. The most widely used plans were designed by Harold Dodge and would be included in any complete set of Dodge and Romig tables.

Let us first examine the procedures of the single level continuous sampling plan. Mr. Dodge has labeled this plan CSP-1 and the procedures are:

A. Begin by inspecting 100% of the items until a given number (i) of the successive good items are found.

B. After i good items are found, begin sampling only a fraction (f) of the items as they pass the inspection point.

C. As soon as one defect is found, revert to 100% inspection and begin the cycle again.

Now let us take a typical CSP-1 plan with i = 100 and f = 0.10. From this let us compute the average fraction inspected (AFI), the AOQ and AOQL, and the characteristic curve.

Let p = incoming % defective

$$q = 1-p$$

$$u = \frac{1-q^i}{pq^i}$$

$$v = \frac{1}{fp}$$

and

$$AFI = \frac{u+fv}{u+v}$$

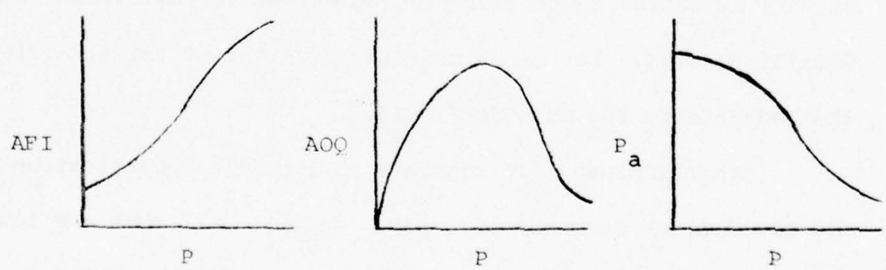
$$AOQ = p(1-\frac{u+fv}{u+v})$$

$$P_a = \frac{v}{u+v}$$

Table 7

p	AFI	AOQ	P_a
0	.10	0	1.00
.01	.2327	.007673	.8526
.02	.4557	.010886	.6047
.03	.7004	.008988	.3329
.04	.8682	.005272	.1465
.05	.9494	.002530	.0562

Using CSP-1 with the selected i and f one can see from Table 6 that as quality deteriorates more and more items will be inspected. Also from the AOQ data, the AOQL can be determined as can the characteristic curve.



This is the same data that is required in selecting optimum plans of the lot by lot type. One merely varies i and f in order to change AFI, AOQL, or the characteristic curve.

As time passed Mr. Dodge designed several other CSP plans. The appropriate sources of this information are listed in the bibliography.

XV. SAMPLING BY VARIABLES

In the plans discussed earlier we were concerned with a go-no go decision--defective or acceptable. However, many items exhibit characteristics that can be measured on a continuous scale and a yes/no decision may not be the optimum method of sampling these items. When we either know or can assume a normal distribution of a characteristic, often times it is more economical to sample using variable plans. The great advantage to variable over attribute plans is in the reduced number of samples generally required to assure the same quality of inspection. The major difficulty with variable plans is the requirement for more sophisticated inspection equipment and more highly trained inspectors. When using either destructive or very expensive inspection procedures the variable plans will usually be used. Let us examine the simplest of variable plans and then advance to the more difficult.

The simplest plan consists of a single specification limit, say the minimum diameter of a rod. We will call this the lower limit, L. Graphically, Figure 8 depicts our product which is normally distributed with a known and relatively constant standard deviation.

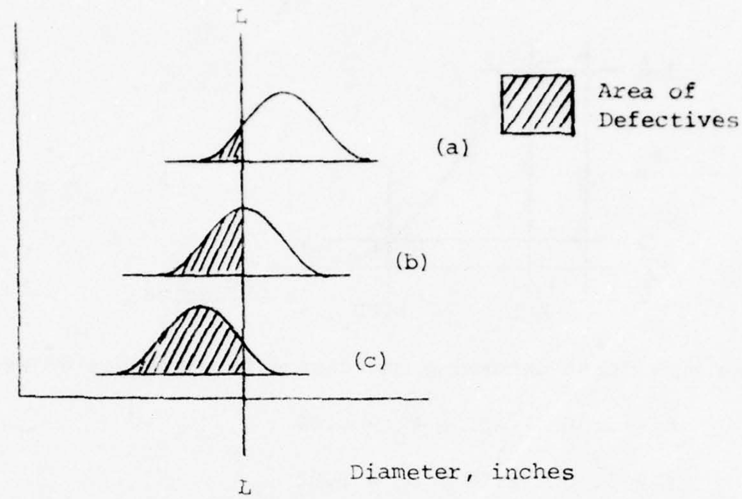


Figure 9

In Figure 9 we note that the distributions a, b, and c have varying amounts of defectives. Our objective will be to select a variable sampling plan that will accept good lots, say (a) and reject bad ones, say (c).

With a given lower limit, L, we select a sample of size n and measure each rod diameter. Next we compute the sample mean, $\overline{X}$ and compare this with our decision rule:

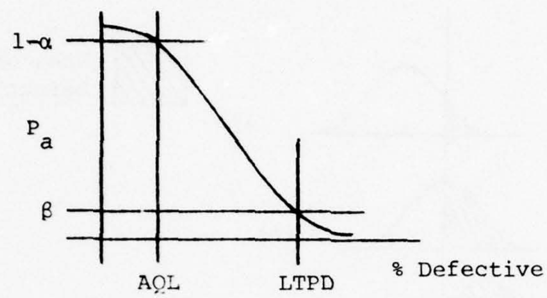
A. If $\overline{X} > K$ accept the lot

B. If $\overline{X} \leq K$ reject

K = acceptance constant

Let us now work an example to show what we need to start and our resultant plan.

From our previous work



or we must first determine our design requirements as we did before.

Let $\alpha = 0.05$ $\quad AQL = P_0 = 0.02$

$\beta = 0.10$ $\quad LTPD = P_1 = 0.08$

We know the process standard deviation to be 10 and the specification lower limit to be 150.

Our design limits are reflected in Figure 10. From this data we will calculate the lot mean values, μ_0 and μ_1 for the appropriate criteria

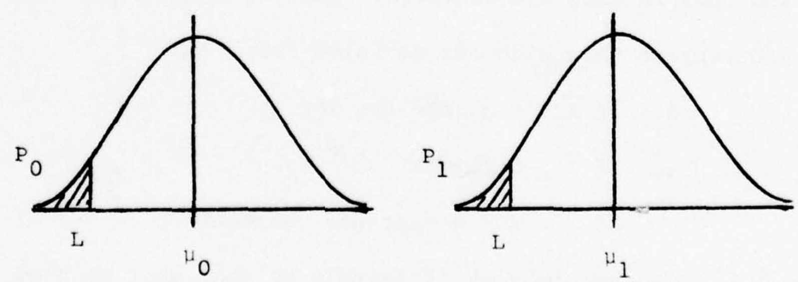


Figure 10

$\underline{\mu_0 \text{ Calculations}}$

$$\frac{L - \mu_0}{\sigma} = - Z_{P_0} = -Z_{.02} = - 2.054$$

$$\mu_0 = 150 + 2.054(10) = 170.54$$

μ_1 Calculations

$$\frac{L - \mu_1}{\sigma} = \cancel{Z}_{P_1} = \cancel{Z}_{.08} = 1.405$$

$$\mu_1 = 150 + 1.405(10) = 164.05$$

Next we establish a relationship between the unknown values of n and k and the given sampling plan requirements, see Figure 11.

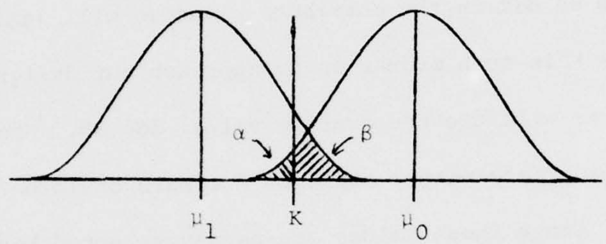


Figure 11

A. $$\frac{K - \mu_0}{\sigma/\sqrt{n}} = -Z_\alpha$$

B. $$\frac{K - \mu_1}{\sigma/\sqrt{n}} = Z_\beta$$

With the above two equations we solve for the unknowns n and K. The results are

$$n = \left(\frac{Z_\alpha + Z_\beta}{Z_{P_0} - Z_{P_1}}\right)^2$$

At this point in our analysis a difficulty arises in most cases because the above equation will not normally result in an integer value. Naturally our sample size must be an integer and therefore rounding is required. This subsequently results in two different values for K. From our example

$$n = \left[\frac{1.282 + 1.645}{2.054 - 1.405}\right]^2 = (4.51)^2 = 20.34$$

$$n \cong 21$$

From A. $K = 170.54 - 1.645\left(\frac{10}{\sqrt{21}}\right) = 166.95$

From B. $K = 164.05 + 1.282\left(\frac{10}{\sqrt{21}}\right) = 166.84$

As we did in the attribute plans, we will again select a compromise K in such manner as to approach our design criteria. In this case we will use the average value, 166.90. Should it be deemed appropriate either the α or β errors could be used as exact criteria. Since these values are rarely selected based upon solid data, the average K is usually sufficient.

Our plan now consists of a sample of size 21 with an acceptance constant of 166.90. Lots will be accepted if the sample mean is greater than 166.90.

Next we may wish to construct the OC curve for our plan. We are able to develop two curves--one based upon percent defective and the other on the mean value of the submitted lots.

Figure 12 depicts the probability of acceptance relative to the acceptance constant.

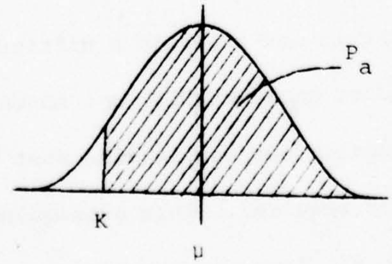


Figure 12

Figure 13 depicts the lot fraction defective relative to the lower limit specification.

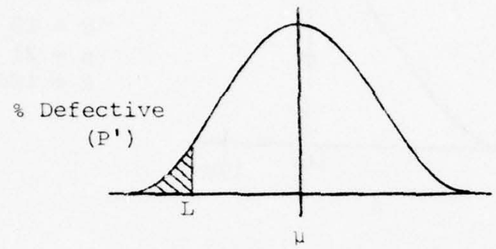


Figure 13

For our example the data has been compiled in Table 7 which will facilitate our constructing the appropriate OC curves.

Table 8

u	Z_1 $\frac{K-\bar{X}}{\sigma/\ n}$	P_a	Z_2 $\frac{L-u}{\sigma}$	P'
160	3.16	0	-1.00	.159
162	2.24	.013	-1.20	.115
164	1.33	.092	-1.40	.081
166	.41	.341	-1.60	.055
168	- .50	.692	-1.80	.036
170	-1.42	.922	-2.00	.023
172	-2.34	.990	-2.20	.014
174	-3.25	1.00	-2.40	.008

Now if we wish to know the probability of accepting a lot with a mean value of 167, we can get this from our chart, Figure 14.

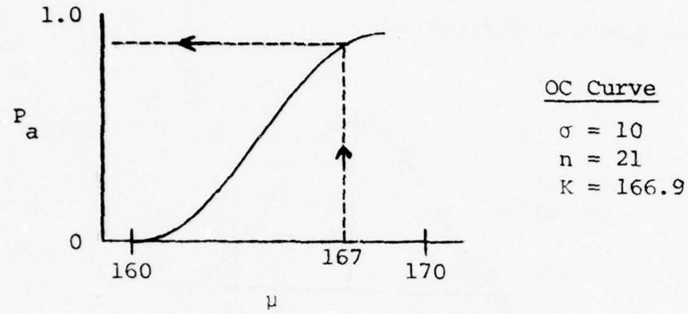


Figure 14

Or should the probability of acceptance as a function of lot quality in percent defectives (Figure 15) be needed.

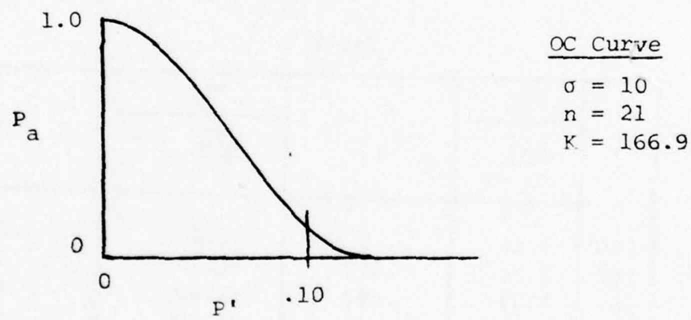


Figure 15

This type of plan is used only when the standard deviation is known and is also relatively constant. Other plans are available for use when the standard deviation is unknown or variable. However, these are beyond the scope of this report.

The two sided problem is an extension of the single specification problem above and can best be described by the use of an example.

Example

The design of a particular coin changer requires that the coins be 0.5000 ± .005 inches in diameter or the changer will not work. Previous work in this area indicates that the variability of the coins received results in a standard deviation of .0018 inches.

Let us examine what the above specification means with respect to the minimum number of defectives possible.

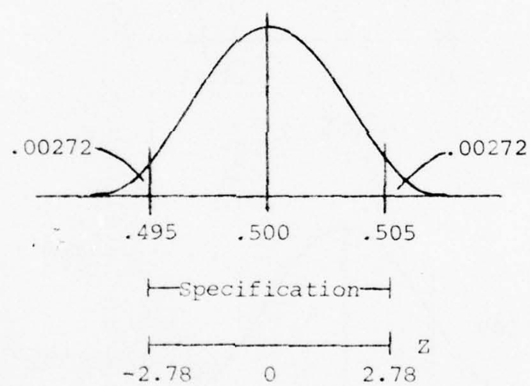


Figure 16

Adding the tails equals 0.00544 fraction defectives. From previous statistics courses we know that any shift of the process average from 0.500 will result in an increase in fraction defectives.

Previous knowledge of the economics of the coin changer and the effects of out of tolerance coins indicates that the following criteria is appropriate:

$$AQL = p_1 = 0.01 \quad (P_a = .95)$$

$$LTPD = p_2 = 0.05 \quad (P_a = .10)$$

Now let us shift the distribution so as to depict the AQL and LTPD cases. Unfortunately a direct approach is unavailable and a cut and try is required. Figures 17 and 18 reflect the results of the above approach.

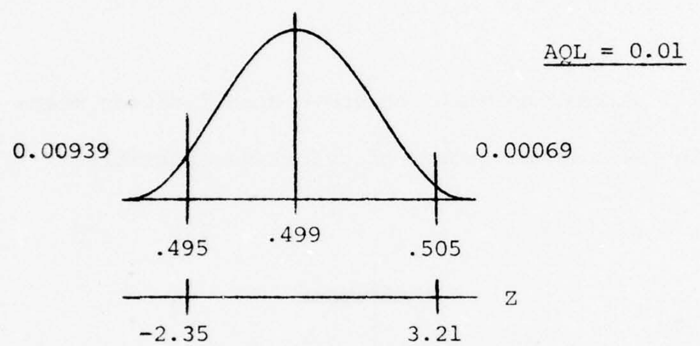


Figure 17

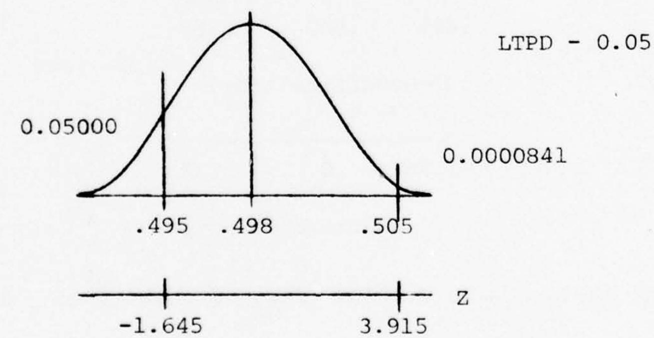


Figure 18

We now have

$$\mu_{AQL} = 0.499$$

$$\mu_{LTPD} = 0.498$$

Since shifts of the means may be either up or down we arbitrarily split the risk and assume that at the AQL level the

$P_a = 1 - \alpha/2$. Similarly at the LTPD level the P_a is equal to $\beta/2$. Therefore,

$$\text{A.}\quad Z_{\alpha/2} = -1.96 = \frac{\bar{X} - .499}{0.0018/\sqrt{n}}$$

$$\text{B.}\quad Z_{\beta/2} = 1.645 = \frac{\bar{X} - .498}{0.0018/\sqrt{n}}$$

Eliminating $\bar{X}$ by subtracting A from B leads to

$$\sqrt{n} = \frac{(3.605)(.0018)}{.001} = 6.489$$

$$n \cong 42$$

Pictorially our solution can be depicted as in Figure 19.

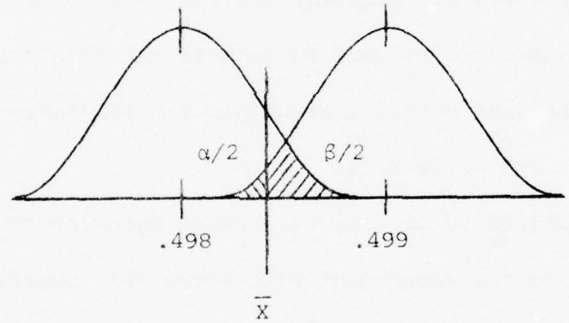


Figure 19

Notice how similar this pictorial is to the similar case using attribute plans.

Now with n = 42 we calculate $\bar{X}$ to be 0.498456. Assuming symmetry we can then figure the upper limit to be 0.5015439.

Thus our plan will be

$n = 42$

$\bar{X}_{sample} \leq 0.49845$, reject

$\bar{X}_{sample} \geq 0.5015439$, reject

Construction of the OC curve is left as an exercise for the student. So is the computation of the required sample size using an attribute plan that guarantees an equal degree of protection.

XVI. MILITARY STANDARD 105D

The MIL-STD 105D is the result of an evolutionary process that began during World War II by the Army Ordnance Corps. The standard 105D was published in 1963 and has remained relatively unchanged. This standard describes not only a sampling plan but also includes the overall strategy that is to be employed. These schemata are considered by some to be more art than science for two people given the same entering arguments can sometimes select different plans and procedures.

The standard is used by government agencies to assure that suppliers provide the government with acceptable quality products. For this reason the AQL is the focal point of the entire standard.

Generally the application of 105D follows the track outlined below:

A. Determine Lot Size.

B. Select Inspection Level.

C. Determine Sample Size Code Letter.

D. Select Sampling Plan.

E. Establish Severity of Inspection.

F. Determine Sample Size and Acceptance Number.

G. Select Sample.

H. Inspect Sample.

With the use of several examples let us now track through 105D and determine how to use this very valuable quality control device.

Example 1

Given: Single Sampling Plan
Normal Inspection
Level II
N = 1500
AQL = 2.5%

Pg 9: (All page numbers refer to page in MIL-STD 105D)

$II \Rightarrow 1500 \Rightarrow K$

Pg 10:

$K \Rightarrow n = 125$

$K \Rightarrow AQL \Rightarrow Ac = 7$

$Re = 8$

Decision: Inspect 125 units and accept the lot if 7 or fewer fail the inspection.

Note: Acceptable Quality Levels (AQL)

% Defective vs Defects/100 Units

.01 to 10.0 : % Def or DHU

15 to 1000 : DHU

$$\% \text{ Defective} = \frac{100 \text{ X Defectives}}{\text{No. Inspected}}$$

$$DHU = \frac{100 \text{ X Defects*}}{\text{No. Inspected}}$$

*Possibly more than one defect on a part.

Example 2

Sample Size vs AQL. In selecting Ac and Re numbers follow the arrows and use the appropriate sample size. With AQL = 0.10

the minimum sample size is 125 (pg 10). Similarly with AQL = 15 defects per hundred units the maximum n = 80. The rule is: Enter with sample size code letter, proceed in this row to the appropriate AQL column and then follow the arrow to Ac and Re row. Then read left to sample size. Note: If "your" AQL is not listed in the table, use the AQL closest but lower than "your" value.

Example 3

Inspection Levels. MIL-STD 105D provides the user with three general and four special inspection levels that are based upon the amount of discrimination desired. This discrimination is reflected in the ratio of lot size to sample size. Normally levels I, II, and III are used for nondestructive types of inspection, whereas S-1 to S-4 is more appropriate for expensive or destructive testing and where small samples are more appropriate. In the interest of cost/risk optimization one should consider the following list as a minimum of things to consider in selecting a plan.

A. OC Curves of Different Plans

B. β and Discrimination Afforded

C. Production Process

D. Process Capability and History

E. Item Complexity

F. Cost vs Importance of Examination

G. Importance of Quality Characteristics

H. α

The following exhibits the typical affect of the general inspection level upon sample size and acceptance number.

N = 1500 Single Sample

AQL = 2.5% Normal Inspection

	General Inspection Level		
	I	II	III
Code Letter	H	K	L
n	50	125	200
Ac	3	7	10

Similar trends are also found under reduced or tightened inspection and with double/multiple plans.

Example 4

Special Inspection Levels. Given the same entering arguments as in Example 3 the very significant decrease can be noted for the Special Inspection Levels.

	Special Inspection Level			
	S-1	S-2	S-3	S-4
Code Letter	C	D	E	G
n	5	5	20	32
Ac	0	0	1	2

In all cases the following relationship holds true.

$$n_{S-1} < n_{S-2} < n_{S-3} < n_{S-4}$$

Example 5

Inconsistencies. When the sample size required of the specific code letter is larger than the lot size, one hundred percent inspection is required. For example:

N = 250 Single Sample

S-3 Level Normal Inspection

AQL = 0.025%

Code Letter is D

With given AQL and D the sample size is 500--screen the lot since $n \geq N$.

Example 6

Plans. Let us now look at a comparison of the single, double, and multiple plans.

N = 1500 Level II

AQL = 1% Normal Inspection

Single Code Ltr = K

n = 125

Ac = 3 Re = 4

Double Code Ltr = K

	Ac	Re
$n_1 = 80$	1	4
$n_2 = 80$	4*	5*

*These numbers reflect the totals and not just the defects in sample 2.

Multiple Code Ltr = K

$n_{Cumulative}$	Ac	Re
32	*	3
64	0	3
96	1	4
128	2	5
160	3	6
192	4	6
224	6	7

*This sample is too small to assure the required AQL.

Example 7

Average Sample Size vs Types of Sampling. Table IX on page 29 depicts the expected differences in the average inspections relative to the three possible plans. In order to use these charts, first compute the expected number of defectives per sample.

$$\text{END} = \frac{n \cdot \text{AQL}}{100}$$

Next determine the acceptance number for the single sampling plan. For this example let END = 5 and C = 10.

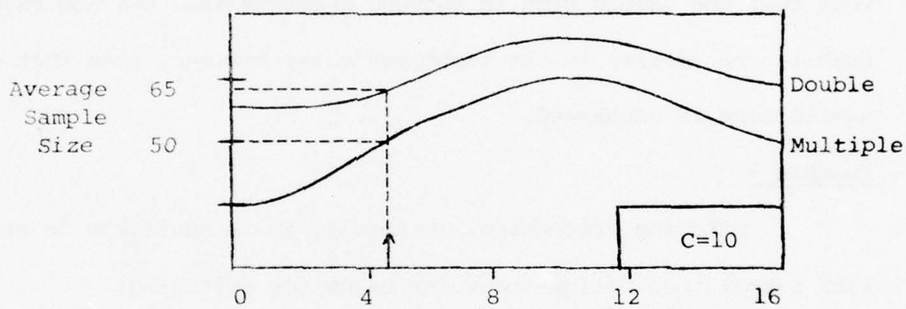


Figure 20

Note in Figure 20 that going from single to multiple sampling will reduce the average sample size to 50% and from single to double to 65% in the example. Care must be taken, however, for inspection time, facilities for storage, increased record keeping, or other administrative constraints may preclude the use of anything but single sampling.

Example 8

Severity of Inspection. MIL-STD 105D is so structured that as quality received improves one may reduce the inspections and similarly as the quality deteriorates, tighten the plan.

Reduced vs Normal:

Given: Code Ltr K
AQL = 2.5

Plan	n_{cum}		Ac No		Re No	
	Norm	Red	Norm	Red	Norm	Red
Single	125	50	7	3	8	6
Double	80	32	3	1	7	5
	160	64	8	4	9	7
Multiple	32	13	0	*	4	4
	64	26	1	0	6	5
	96	39	3	1	8	6

Note that the sample size is reduced approximately 60% and rejection numbers are smaller in the tightened case; however, note that the sample size is unchanged.

Example 9

Switching Procedures. Generally it is advisable to start with normal then follow the rules below for switching:

A. Normal to tightened may be initiated when 2 out of 5 lots fail.

B. Tightened to normal may be initiated when 5 consecutive lots pass inspection.

C. Normal to reduced is permitted when

1. 10 or more have passed and

2. the total number of defects do not exceed the limit as specified on Table VIII, 28. (If double or multiple sampling include all samples inspected.), and

3. production is steady, and

4. reduced inspection is considered desirable.

D. Reduced to normal is initiated when

1. a lot is rejected, <u>or</u>

2. the acceptance number is exceeded but the rejection number is not reached, <u>or</u>

3. production becomes irregular, <u>or</u>

4. other conditions change.

Let us now look at the process as lots come out of the inspection point:

R = Rejected Lot

A	Plan	Normal		Tightened
B	Lot No	1 2 3 4 5 6	7 8 9 10 11	12
C	Ac/Re		R R	
D	Rule		2 out of 5	

A	Tightened	Normal	Reduced	Normal
B	12 13 14 15 16	17 - 26	27 28 29	
C		*	R	
D	5 Good			

* 62 Defectives in 10 lots

Given: AQL = 2.5%

n_{tot} = 3150

Table VIII: Limit = 67

This is a dynamic system that will require intelligent and well trained personnel to make it work. If you can't meet these constraints then do not use this part of MIL-STD 105D.

<u>Example 10</u>

The AOQL Sampling Plan. As we showed earlier, often the consumer wants to set an absolute lower quality limit on the lots that are accepted. Tables V-A and V-B can assure the consumer of the desired limit.

Given: AOQL = 5%
N = 960
Code Ltr = J
n = 80

$$AOQL = F(1 - \frac{n}{N})$$

$$5 = F(1 - 80/960)$$

F = Value in Table V

F = 5.45%

Enter Table V with J. Proceed to the right to 5.45 or less, then go up the column to the AQL. J ⇒ 4.0 ⇒ AQL = 2.5% , with this AQL and code letter enter Table II and find Ac/Re (5 and 6).

Example 11

Limiting Quality Protection. Previous work has been associated with continuous production of lots and are designed with the use of the supplier's risk. If we are faced with isolated lots we can use the consumer's risk and select the proper plan. Let's continue with our example.

Given: N = 3600
β = 10%
LTPD = 5% (LQ)

Determine Code letter = L

From Table VI-A

Enter at Code Ltr = L and proceed to a value equal to or less than LQ (5%). In this case 4.6 is the largest value less than 5. Now proceed up to column top where AQL = 1.0. Now to Table II-A with AQL and Code letter to find n, Ac, and Re which are 200, 5, and 6 respectively.

Example 12

Combining LQ and AQL. As we have done previously, we wish to select a plan that meets both producer and consumer requirements. Figure 21 depicts typical entering arguments.

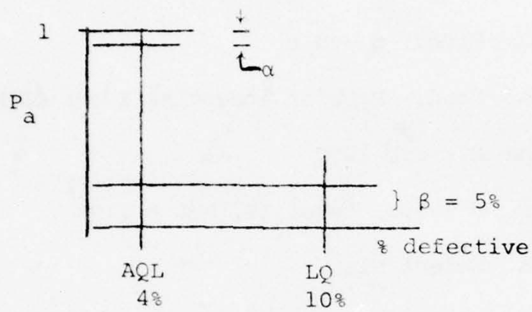


Figure 21

Given: AQL = 4%   Level II
LQ = 10%   β = 5%
N = 2000

The procedure consists of finding acceptance and rejection numbers for both plans and selecting the smaller set. This will assure the users of at least the minimum protection required, but normally will not exactly satisfy both risks.

Once this section has been mastered the student can consider himself to be well versed in the workings of attribute sampling plans that are used by the Defense Department and industry.

Since practice makes perfect or some such thing, we have included the following set of Quality Control problems for student use:

A. Given: $n = 100$
$c = 2,3,4$

1. Construct the 3 OC Curves

2. Construct the 3 AOQ Curves

3. Determine Worst Quality (AOQL) for each plan.

B. Design a Plan: $\alpha = \beta = .10$
AQL = .01
LTPD = .10

1. Find: n and c

2. Find: Prob of accepting a lot with 5% defectives.

C. Use MIL-STD 105D

Given: N = 500, Level II, AQL = 1.5%

1. Select Plan

2. If 3 out of first five lots fail inspection, what action should be taken. New plan?

D. Variable Plan

$\alpha = .05$ AQL = .01

$\beta = .10$ LTPD = .10

Lower Limit = 100

$\sigma = 10$

1. Design Plan: $\tilde{n} =$
$\tilde{k} =$

2. What is n and k?

E. Show that with AOQL = 2%, N = 1000, p' = 1% . A plan of n = 65 and c = 2 will minimize the ATI.

F. With an accpetance no. = 3 select the sample size that will result in an AOQL = 2% and $p'_m = .03$.

G. Compare sample sizes of single, double, and multiple for N = 300, AQL = 2.5%, do same for tightened and reduced.

H. With $N = 350$, $\beta = .05$, LTPD = .10 and a process average 2% compute ATI.

I. With $N = 1000$ (Code J) AQL = 6.5% AC = 5 9
AC = 12 13

$n = 50/50$

Start in Normal

From random No. Table - Use Last Digit - Get No. of Def in sample

Lot #	1	2	3	4	etc
No. Def in n_1					
n_2					

Normal/Reduced/Tightened
Sometimes n_2 will not be used

J. Lt Min E. Sample wants to design a sampling plan that will have producer and consumer risks at 0.10. He figures that a 2% defective lot can be considered "good" and an 8% defective lot is "bad". His lots will be very large compared to his expected sample size. Capt Dregnaught III wants to know the probability of accepting a lot that is 5% defective with the plan designed by the lieutenant. *Compute n, c, and* answer the captain's question.

K. Using MIL-STD 105D

1. Select a single sampling plan (attribute) for a lot of size 5000 with inspection level II and an AQL of 1.5%.

2. Utilizing the above plan resulted in 2 out of the first five lots being rejected. What action should be taken if any. If a new plan should be selected, what is it?

L. Major Eye M. A. Brain wants to use a variable sampling plan to QC the headquarters paper flow for last year. His headquarters must turn out 100 letters per day to be satisfactory and he knows that the standard deviation of letters per day is 20. He will take $\alpha = .05$ and $\beta = .10$, AQL = .01 and LTPD = .10. With the above constraints how many days would make up the sample and what would be the accept/reject constant?

M. Show that with AOQL = 2%
N = 1000
Process Ave = 1%

an n = 65 and c = 2 will minimize the ATI. Also compute ATI for this plan.

N. You have been assigned to set up an inspection plan for large quantities of ammunition coming aboard your ship. Because of your outstanding training program, no defectives would be missed in screening or in sampling. Shop replacement costs and inspection costs are estimated at $10.00 and $.10 respectively. Because of the packaging situation, you have determined that lot sizes of 500 would be appropriate. Higher authority has dictated that you will either sample or screen the incoming lots. You will use a General Inspection Level of II, and AQL of 2.5%. You also can expect the percent defectives in the lot to be 4%.

1. Determine the minimum cost plan (screen or sample).

______________________.

2. Determine the cost per unit under your plan selected in 1.

______________________.

3. Under your plan, what would the total cost per lot amount to if the incoming quality inproved to 1% defective?

____________________.

O. As a member of an inspection team, you have been asked to determine the worst quality that can be expected to flow from the following rectifying inspection plan: n = 100, c = 3.

1. Determine worst quality that can flow out of this inspection system. ____________________.

2. How would increasing the sample size to 200 and the acceptance number of 6 affect 1. above?____________________.

P. Select a double sampling plan based upon the following criteria:

General Inspection Level	- II
Lot size	- 3000
AQL	- 1.5

with your plan, inspect the following lots and take appropriate action.

Lot #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	3	6	1	4	2	4	2	0	1	3	1	0	2	3	2	1	3	2	3	5
B	2	1	4	2	2	3	1	3	2	1	2	4	1	0	2	1	4	1	2	0

A = Def in First Sample
B = Def in Second Sample (when used)

Plans		

Start Inspection at Normal

1. Switch to ________________ for Lot # ________.

2. Switch to ________________ for Lot # ________.

3. Switch to __________________ for Lot #__________.

4. Switch to __________________ for Lot #__________.

5. Switch to __________________ for Lot #__________.

Q. CINCSAC has decided to use a variable sampling plan to evaluate the combat capability of the SAC force. He wants a plan that will, 95% of the time, identify a good rating of .01. He is also concerned about a bad rating of .10 and will accept this bad rating as good only 5% of the time. Each aircrew that is evaluated receives a score with the lower limit (minimum passing score) being 100 points. Recent exercises indicate a standard deviation of 5 is representative of the SAC crews evaluated under this system.

1. Develop a variable sampling plan that will meet CINCSAC's objectives.

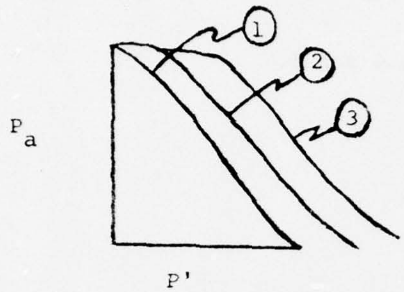
$n \cong$ __________________

$k \cong$ __________________

2. In your own words, state what n and k are in this problem.

The student is also advised to review the problems on page 262-3 in "Quality Control for Managers and Engineers" by E. G. Kirkpatrick.

R.



n - constant

1, 2, 3 are O.C. curves

Circle Correct Answer:

a. At a given P', as the sample size increases, the P_a (increases, decreases).

b. The c for 3 is (less than, more than) the c for 1 .

c. If when constructing O.C. curves the AQL and the α error remain constant what happens to the β error as the sample size increases (gets smaller, gets larger).

S. On the average, what would be the costs associated with inspecting a lot if rectifying inspections would be used for the following data:

N = 1000
Cost/Inspection = $0.01
C = 6
AOQL = 2%
P_a = 90%

Cost = ____________________.

T. The Big Mushroom Counter has designed a sampling plan of n = 100 and c = 1. If AQL and LTPD are 0.01 and 0.04 respectively, what are the α and β risks?

α = ____________________.

β = ____________________.

U. Use MIL-STD-105D for questions 4 and 5.

Given: N = 4000
AQL = .25%
Level = II
Multiple Sampling Plan

a. Find:

n							
Ac							
Re							

b. If the number of defects follows this pattern, state the proper course of action.

SAMPLE	DEFECTS	ACTION
1	0	
2	1	
3	1	
4	0	
5	2	
6	1	
7	3	

V. Estimate the average double and multiple sample sizes given n = 100, C - 10, and 2% defectives.

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APPENDIX A

MIL-STD-105D
NOTICE-1 (NAVY)
1 November 1963

101

MILITARY STANDARD

SAMPLING PROCEDURES AND TABLES

FOR INSPECTION BY ATTRIBUTES

The designations used for Inspection Levels in MIL-STD-105D differ from those in the previous issue, MIL-STD-105C. This notice is issued as an interim measure to provide conversion information, as follows:

For Specified Small Sample Inspection Level MIL-STD-105C	Use Special Inspection Level MIL-STD-105D
L-1 and L-2	S-1
L-3 and L-4	S-2
L-5 and L-6	S-3
L-7 and L-8	S-4

Preparing Activity:
Navy-Weps

☆ U. S. GOVERNMENT PRINTING OFFICE: 1971 -433-696/4766

101

MILITARY STANDARD

SAMPLING PROCEDURES AND TABLES FOR INSPECTION BY ATTRIBUTES

TO ALL ACTIVITIES:

1. The following corrections should be made to MIL-STD-105D:

(a) *Page ii*, lines 2, 3, and 4: Change to read "Recommended corrections, additions or deletions should be addressed to Director of Quality Assurance, U.S. Army Edgewood Arsenal, ATTN: SMUEA-QA-E, Edgewood Arsenal, Md., 21010."

(b) *Page 2*, paragraph 3.2, line 3: Change "hunderd" to read "hundred".

(c) *Page 4*, paragraph 6.4, line 9 Change "for" to read "only".

(d) *Page 5*, paragraph 8.2, line 5: Change "batchs" to read "batches".

(e) *Page 5*, paragraph 8.2, line 6: Change "require change" to read "require a change".

(f) *Page 5*, paragraph 8.2, lines 6, 7, and 8: Delete the sentence that reads,"The switching procedures given below require a change".

(g) *Page 7*, paragraph 10.1, lines 5 and 6: Change "10.1.3, 10.1.4, and 10.1.5" to read "10.1.3 and 10.1.4". Delete reference to 10.1.5.

(h) *Page 8*, paragraph 11.1, line 2: Change "larger then 80" to read "larger than 80".

(i) *Page 9*, table I: Add the following footnote beneath table I:

Note.

Small sample inspection levels of MIL-STD-105C	*Convert to these special inspection levels*
L-1 and L-2	S-1
L-3 and L-4	S-2
L-5 and L-6	S-3
L-7 and L-8	S-4

(j) *Page 29*, table IX, vertical scale on three charts: Change "$\frac{3}{4}$n, $\frac{1}{2}$n, $\frac{1}{4}$n" to read ".75n, .50n, .25n".

(k) *Page 36*, table X-D-1: Add footnote, "Note: Binomial distribution used for percent defective computations; Poisson for defects per hundred units".

(l) *Page 46*, table X-J-1: Change footnote to read, "Note: Binomial distribution used for percent defective computations; Poisson for defects per hundred units".

(m) *Page 48*, table X-K-1: For Pa=75.0 and AQL=0.65, change "0.382" to read "1.382".

(n) *Page 52*, table X-M-1: In line below row of AQL values, change "dejects" to read "defects".

(o) *Page 54*, table X-N-1: In the footnote, change "Pisson" to read "Poisson".

(p) *Page 56*, table X-P-1: In the footnote, change "Poission" to read "Poisson".

(q) *Page 63*, for the term Reduced inspection: Change paragraph references from "8.2 and 8.3.3" to read "8.2, 8.3.3 and 10.1.4".

(r) *Page 64*, mailing address for the U.S. Government Printing Office: Delete reference to zone 25 and, after D.C., add the ZIP code "20402".

2. The following is a cumulative list of earlier changes: Notice 1 (Navy) dated 1 November 1963 provided a table of conversion from the small sample inspection levels (L-1, L-2, etc.) of MIL-STD-105C, to the special inspection levels (S-1, etc.) of MIL-STD-105D. The same conversion information is covered by correction 1(i) above to page 9, table I.

3. Retain this notice and insert before the table of contents.

4. Holders of MIL-STD-105D will verify that corrections indicated above have been entered and will destroy the previous notice. Activities which stock these notices for issue are warned that each notice, together with its appended revised pages if any, is in effect a separate publication to be retained until the military standard is completely revised or canceled.

MIL-STD-105D
29 April 1963

SUPERSEDING
MIL-STD-105C
18 July 1961

MILITARY STANDARD

SAMPLING PROCEDURES AND TABLES FOR INSPECTION BY ATTRIBUTES

MIL-STD-105D
29 APRIL 1963

DEPARTMENT OF DEFENSE
Washington 25, D. C.

SAMPLING PROCEDURES AND TABLES FOR INSPECTION BY ATTRIBUTES

MIL-STD-105D 29 APRIL 1963

1. This standard has been approved by the Department of Defense and is mandatory for use by the Departments of the Army, the Navy, the Air Force and the Defense Supply Agency. This revision supersedes MIL-STD-105C, dated 18 July 1961.

2. This publication provides sampling procedures and reference tables for use in planning and conducting inspection by attributes. This publication was developed by a working group representing the military services of Canada, the United Kingdom and the United States of America with the assistance and cooperation of American and European organizations for quality control. The international designation of this document is ABC-STD-105. When revision or cancellation of this standard is proposed, the departmental custodians will inform their respective Departmental Standardization Office so that appropriate action may be taken respecting the international agreement concerned.

3. The U.S. Army Munitions Command is designated as preparing activity for this standard. Recommended corrections, additions, or deletions should be addressed to the Commanding Officer, U. S. Army CBR Engineering Office, Attn: SMUCE-ED-S, Army Chemical Center, Maryland.

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C., 20402 - Price 40 cents

CONTENTS

TABLES

SAMPLING PROCEDURES AND TABLES FOR INSPECTION BY ATTRIBUTES

1. SCOPE

1.1 PURPOSE. This publication establishes sampling plans and procedures for inspection by attributes. When specified by the responsible authority, this publication shall be referenced in the specification, contract, inspection instructions, or other documents and the provisions set forth herein shall govern. The "responsible authority" shall be designated in one of the above documents.

1.2 APPLICATION. Sampling plans designated in this publication are applicable, but not limited, to inspection of the following:

a. End items.

b. Components and raw materials.

c. Operations.

d. Materials in process.

e. Supplies in storage.

f. Maintenance operations.

g. Data or records.

h. Administrative procedures.

These plans are intended primarily to be used for a continuing series of lots or batches. The plans may also be used for the inspection of isolated lots or batches, but, in this latter case, the user is cautioned to consult the operating characteristic curves to find a plan which will yield the desired protection (see 11.6).

1.3 INSPECTION. Inspection is the process of measuring, examining, testing, or otherwise comparing the unit of product (see 1.5) with the requirements.

1.4 INSPECTION BY ATTRIBUTES. Inspection by attributes is inspection whereby either the unit of product is classified simply as defective or nondefective, or the number of defects in the unit of product is counted, with respect to a given requirement or set of requirements.

1.5 UNIT OF PRODUCT. The unit of product is the thing inspected in order to determine its classification as defective or nondefective or to count the number of defects. It may be a single article, a pair, a set, a length, an area, an operation, a volume, a component of an end product, or the end product itself. The unit of product may or may not be the same as the unit of purchase, supply, production, or shipment.

2. CLASSIFICATION OF DEFECTS AND DEFECTIVES

2.1 METHOD OF CLASSIFYING DEFECTS. A classification of defects is the enumeration of possible defects of the unit of product classified according to their seriousness. A defect is any nonconformance of the unit of product with specified requirements. Defects will normally be grouped into one or more of the following classes; however, defects may be grouped into other classes, or into subclasses within these classes.

2.1.1 CRITICAL DEFECT. A critical defect is a defect that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using, maintaining, or depending upon the product; or a defect that judgment and experience indicate is likely to prevent performance of the tactical function of a major end item such as a ship, aircraft, tank, missile or space vehicle. NOTE: For a special provision relating to critical defects, see 6.3.

2.1.2 MAJOR DEFECT. A major defect is a defect, other than critical, that is likely to result in failure, or to reduce materially the usability of the unit of product for its intended purpose.

2.1.3 MINOR DEFECT. A minor defect is a defect that is not likely to reduce materially the usability of the unit of product for its intended purpose, or is a departure from established standards having little bearing on the effective use or operation of the unit.

2.2 METHOD OF CLASSIFYING DEFECTIVES. A defective is a unit of product which contains one or more defects. Defectives will usually be classified as follows:

2.2.1 CRITICAL DEFECTIVE. A critical defective contains one or more critical defects and may also contain major and or minor defects. NOTE: For a special provision relating to critical defectives, see 6.3.

2.2.2 MAJOR DEFECTIVE. A major defective contains one or more major defects, and may also contain minor defects but contains no critical defect.

2.2.3 MINOR DEFECTIVE. A minor defective contains one or more minor defects but contains no critical or major defect.

3. PERCENT DEFECTIVE AND DEFECTS PER HUNDRED UNITS

3.1 EXPRESSION OF NONCONFORMANCE. The extent of nonconformance of product shall be expressed either in terms of percent defective or in terms of defects per hundred units.

3.2 PERCENT DEFECTIVE. The percent defective of any given quantity of units of product is one hunderd times the number of defective units of product contained therein divided by the total number of units of product, i.e.:

$$\text{Percent defective} = \frac{\text{Number of defectives}}{\text{Number of units inspected}} \times 100$$

3.3 DEFECTS PER HUNDRED UNITS. The number of defects per hundred units of any given quantity of units of product is one hundred times the number of defects contained therein (one or more defects being possible in any unit of product) divided by the total number of units of product, i.e.:

$$\text{Defects per hundred units} = \frac{\text{Number of defects}}{\text{Number of units inspected}} \times 100$$

4. ACCEPTABLE QUALITY LEVEL (AQL)

4.1 USE. The AQL, together with the Sample Size Code Letter, is used for indexing the sampling plans provided herein.

4.2 DEFINITION. The AQL is the maximum percent defective (or the maximum number of defects per hundred units) that, for purposes of sampling inspection, can be considered satisfactory as a process average (see 11.2).

4.3 NOTE ON THE MEANING OF AQL. When a consumer designates some specific value of AQL for a certain defect or group of defects, he indicates to the supplier that his (the consumer's) acceptance sampling plan will accept the great majority of the lots or batches that the supplier submits, provided the process average level of percent defective (or defects per hundred units) in these lots or batches be no greater than the designated value of AQL. Thus, the AQL is a designated value of percent defective (or defects per hundred units) that the consumer indicates will be accepted most of the time by the acceptance sampling procedure to be used. The sampling plans provided herein are so arranged that the probability of acceptance at the designated AQL value depends upon the sample size, being generally higher for large samples than for small ones, for a given AQL. The AQL alone does not describe the protection to the consumer for individual lots or batches but more directly relates to what might be expected from a series of lots or batches, provided the steps indicated in this publication are taken. It is necessary to refer to the operating characteristic curve of the plan, to determine what protection the consumer will have.

4.4 LIMITATION. The designation of an AQL shall not imply that the supplier has the right to supply knowingly any defective unit of product.

4.5 SPECIFYING AQLs. The AQL to be used will be designated in the contract or by the responsible authority. Different AQLs may be designated for groups of defects considered collectively, or for individual defects. An AQL for a group of defects may be designated in addition to AQLs for individual defects, or subgroups, within that group. AQL values of 10.0 or less may be expressed either in percent defective or in defects per hundred units; those over 10.0 shall be expressed in defects per hundred units only.

4.6 PREFERRED AQLs. The values of AQLs given in these tables are known as preferred AQLs. If, for any product, an AQL be designated other than a preferred AQL, these tables are not applicable.

5. SUBMISSION OF PRODUCT

5.1 LOT OR BATCH. The term lot or batch shall mean "inspection lot" or "inspection batch," i.e., a collection of units of product from which a sample is to be drawn and inspected to determine conformance with the acceptability criteria, and may differ from a collection of units designated as a lot or batch for other purposes (e.g., production, shipment, etc.).

5.2 FORMATION OF LOTS OR BATCHES. The product shall be assembled into identifiable lots, sublots, batches, or in such other manner as may be prescribed (see 5.4). Each lot or batch shall, as far as is practicable,

5. SUBMISSION OF PRODUCT (Continued)

consist of units of product of a single type, grade, class, size, and composition, manufactured under essentially the same conditions, and at essentially the same time.

5.3 LOT OR BATCH SIZE. The lot or batch size is the number of units of product in a lot or batch.

5.4 PRESENTATION OF LOTS OR BATCHES. The formation of the lots or batches, lot or batch size, and the manner in which each lot or batch is to be presented and identified by the supplier shall be designated or approved by the responsible authority. As necessary, the supplier shall provide adequate and suitable storage space for each lot or batch, equipment needed for proper identification and presentation, and personnel for all handling of product required for drawing of samples.

6. ACCEPTANCE AND REJECTION

6.1 ACCEPTABILITY OF LOTS OR BATCHES. Acceptability of a lot or batch will be determined by the use of a sampling plan or plans associated with the designated AQL or AQLs.

6.2 DEFECTIVE UNITS. The right is reserved to reject any unit of product found defective during inspection whether that unit of product forms part of a sample or not, and whether the lot or batch as a whole is accepted or rejected. Rejected units may be repaired or corrected and resubmitted for inspection with the approval of, and in the manner specified by, the responsible authority.

6.3 SPECIAL RESERVATION FOR CRITICAL DEFECTS. The supplier may be required at the discretion of the responsible authority to inspect every unit of the lot or batch for critical defects. The right is reserved to inspect every unit submitted by the supplier for critical defects, and to reject the lot or batch immediately, when a critical defect is found. The right is reserved also to sample, for critical defects, every lot or batch submitted by the supplier and to reject any lot or batch if a sample drawn therefrom is found to contain one or more critical defects.

6.4 RESUBMITTED LOTS OR BATCHES. Lots or batches found unacceptable shall be resubmitted for reinspection only after all units are re-examined or retested and all defective units are removed or defects corrected. The responsible authority shall determine whether normal or tightened inspection shall be used, and whether reinspection shall include all types or classes of defects or for the particular types or classes of defects which caused initial rejection.

7. DRAWING OF SAMPLES

7.1 SAMPLE. A sample consists of one or more units of product drawn from a lot or batch, the units of the sample being selected at random without regard to their quality. The number of units of product in the sample is the sample size.

7.2 REPRESENTATIVE SAMPLING. When appropriate, the number of units in the sample shall be selected in proportion to the size of sublots or subbatches, or parts of the lot or batch, identified by some rational criterion.

7. DRAWING OF SAMPLES (Continued)

When representative sampling is used, the units from each part of the lot or batch shall be selected at random.

7.3 TIME OF SAMPLING. Samples may be drawn after all the units comprising the lot or batch have been assembled, or samples may be drawn during assembly of the lot or batch.

7.4 DOUBLE OR MULTIPLE SAMPLING. When double or multiple sampling is to be used, each sample shall be selected over the entire lot or batch.

8. NORMAL, TIGHTENED AND REDUCED INSPECTION

8.1 INITIATION OF INSPECTION. Normal inspection will be used at the start of inspection unless otherwise directed by the responsible authority.

8.2 CONTINUATION OF INSPECTION. Normal, tightened or reduced inspection shall continue unchanged for each class of defects or defectives on successive lots or batchs except where the switching procedures given below require change. The switching procedures given below require a change. The switching procedures shall be applied to each class of defects or defectives independently.

8.3 SWITCHING PROCEDURES.

8.3.1 NORMAL TO TIGHTENED. When normal inspection is in effect, tightened inspection shall be instituted when 2 out of 5 consecutive lots or batches have been rejected on original inspection (i.e., ignoring resubmitted lots or batches for this procedure).

8.3.2 TIGHTENED TO NORMAL. When tightened inspection is in effect, normal inspection shall be instituted when 5 consecutive lots or batches have been considered acceptable on original inspection.

8.3.3 NORMAL TO REDUCED. When normal inspection is in effect, reduced inspection shall be instituted providing that all of the following conditions are satisfied:

a. The preceding 10 lots or batches (or more, as indicated by the note to Table VIII) have been on normal inspection and none has been rejected on original inspection; and

b. The total number of defectives (or defects) in the samples from the preceding 10 lots or batches (or such other number as was used for condition "a" above) is equal to or less than the applicable number given in Table VIII. If double or multiple sampling is in use, all samples inspected should be included, not "first" samples only; and

c. Production is at a steady rate; and

d. Reduced inspection is considered desirable by the responsible authority.

8.3.4 REDUCED TO NORMAL. When reduced inspection is in effect, normal inspection shall be instituted if any of the following occur on original inspection:

a. A lot or batch is rejected; or

b. A lot or batch is considered acceptable under the procedures of 10.1.4; or

c. Production becomes irregular or delayed; or

d. Other conditions warrant that normal inspection shall be instituted.

8.4 DISCONTINUATION OF INSPECTION. In the event that 10 consecutive lots or batches remain on tightened inspection (or such other number as may be designated by the responsible authority), inspection under the provisions of this document should be discontinued pending action to improve the quality of submitted material.

9. SAMPLING PLANS

9.1 SAMPLING PLAN. A sampling plan indicates the number of units of product from each lot or batch which are to be inspected (sample size or series of sample sizes) and the criteria for determining the acceptability of the lot or batch (acceptance and rejection numbers).

9.2 INSPECTION LEVEL. The inspection level determines the relationship between the lot or batch size and the sample size. The inspection level to be used for any particular requirement will be prescribed by the responsible authority. Three inspection levels: I, II, and III, are given in Table I for general use. Unless otherwise specified, Inspection Level II will be used. However, Inspection Level I may be specified when less discrimination is needed, or Level III may be specified for greater discrimination. Four additional special levels: S-1, S-2, S-3 and S-4, are given in the same table and may be used where relatively small sample sizes are necessary and large sampling risks can or must be tolerated.

NOTE: In the designation of inspection levels S-1 to S-4, care must be exercised to avoid AQLs inconsistent with these inspection levels.

9.3 CODE LETTERS. Sample sizes are designated by code letters. Table I shall be used to find the applicable code letter for the particular lot or batch size and the prescribed inspection level.

9.4 OBTAINING SAMPLING PLAN. The AQL and the code letter shall be used to obtain the sampling plan from Tables II, III or IV. When no sampling plan is available for a given combination of AQL and code letter, the tables direct the user to a different letter. The sample size to be used is given by the new code letter not by the original letter. If this procedure leads to different sample sizes for different classes of defects, the code letter corresponding to the largest sample size derived may be used for all classes of defects when designated or approved by the responsible authority. As an alternative to a single sampling plan with an acceptance number of 0, the plan with an acceptance number of 1 with its correspondingly larger sample size for a designated AQL (where available), may be used when designated or approved by the responsible authority.

9.5 TYPES OF SAMPLING PLANS. Three types of sampling plans: Single, Double and Multiple, are given in Tables II, III and IV, respectively. When several types of plans are available for a given AQL and code letter, any one may be used. A decision as to type of plan, either single, double, or multiple, when available for a given AQL and code letter, will usually be based upon the comparison between the administrative difficulty and the average sample sizes of the available plans. The average sample size of multiple plans is less than for double (except in the case corresponding to single acceptance number 1) and both of these are always less than a single sample size. Usually the administrative difficulty for single sampling and the cost per unit of the sample are less than for double or multiple.

10. DETERMINATION OF ACCEPTABILITY

10.1 PERCENT DEFECTIVE INSPECTION. To determine acceptability of a lot or batch under percent defective inspection, the applicable sampling plan shall be used in accordance with 10.1.1, 10.1.2, 10.1.3, 10.1.4, and 10.1.5.

10.1.1 SINGLE SAMPLING PLAN. The number of sample units inspected shall be equal to the sample size given by the plan. If the number of defectives found in the sample is equal to or less than the acceptance number, the lot or batch shall be considered acceptable. If the number of defectives is equal to or greater than the rejection number, the lot or batch shall be rejected.

10.1.2 DOUBLE SAMPLING PLAN. The number of sample units inspected shall be equal to the first sample size given by the plan. If the number of defectives found in the first sample is equal to or less than the first acceptance number, the lot or batch shall be considered acceptable. If the number of defectives found in the first sample is equal to or greater than the first rejection number, the lot or batch shall be rejected. If the number of defectives found in the first sample is between the first acceptance and rejection numbers, a second sample of the size given by the plan shall be inspected. The number of defectives found in the first and second samples shall be accumulated. If the cumulative number of defectives is equal to or less than the second acceptance number, the lot or batch shall be considered acceptable. If the cumulative number of defectives is equal to or greater than the second rejection number, the lot or batch shall be rejected.

10.1.3 MULTIPLE SAMPLE PLAN. Under multiple sampling, the procedure shall be similar to that specified in 10.1.2, except that the number of successive samples required to reach a decision may be more than two.

10.1.4 SPECIAL PROCEDURE FOR REDUCED INSPECTION. Under reduced inspection, the sampling procedure may terminate without either acceptance or rejection criteria having been met. In these circumstances, the lot or batch will be considered acceptable, but normal inspection will be reinstated starting with the next lot or batch (see 8.3.4 (b)).

10.2 DEFECTS PER HUNDRED UNITS INSPECTION. To determine the acceptability of a lot or batch under Defects per Hundred Units inspection, the procedure specified for Percent Defective inspection above shall be used, except that the word "defects" shall be substituted for "defectives."

11. SUPPLEMENTARY INFORMATION

11.1 OPERATING CHARACTERISTIC CURVES. The operating characteristic curves for normal inspection, shown in Table X (pages 30–62), indicate the percentage of lots or batches which may be expected to be accepted under the various sampling plans for a given process quality. The curves shown are for single sampling; curves for double and multiple sampling are matched as closely as practicable. The O. C. curves shown for AQLs greater than 10.0 are based on the Poisson distribution and are applicable for defects per hundred units inspection; those for AQLs of 10.0 or less and sample sizes of 80 or less are based on the binomial distribution and are applicable for percent defec-

tive inspection; those for AQLs of 10.0 or less and sample sizes larger then 80 are based on the Poisson distribution and are applicable either for defects per hundred units inspection, or for percent defective inspection (the Poisson distribution being an adequate approximation to the binomial distribution under these conditions). Tabulated values, corresponding to selected values of probabilities of acceptance (P_a, in percent) are given for each of the curves shown, and, in addition, for tightened inspection, and for defects per hundred units for AQLs of 10.0 or less and sample sizes of 80 or less.

11.2 PROCESS AVERAGE. The process average is the average percent defective or average number of defects per hundred units (whichever is applicable) of product submitted by the supplier for original inspection. Original inspection is the first inspection of a particular quantity of product as distinguished from the inspection of product which has been resubmitted after prior rejection.

11.3 AVERAGE OUTGOING QUALITY (AOQ). The AOQ is the average quality of outgoing product including all accepted lots or batches, plus all rejected lots or batches after the rejected lots or batches have been effectively 100 percent inspected and all defectives replaced by nondefectives.

11.4 AVERAGE OUTGOING QUALITY LIMIT (AOQL). The AOQL is the maximum of the AOQs for all possible incoming qualities for a given acceptance sampling plan. AOQL values are given in Table V-A for each of the single sampling plans for normal inspection and in Table V-B for each of the single sampling plans for tightened inspection.

11.5 AVERAGE SAMPLE SIZE CURVES. Average sample size curves for double and multiple sampling are in Table IX. These show the average sample sizes which may be expected to occur under the various sampling plans for a given process quality. The curves assume no curtailment of inspection and are approximate to the extent that they are based upon the Poisson distribution, and that the sample sizes for double and multiple sampling are assumed to be 0.631n and 0.25n respectively, where n is the equivalent single sample size.

11.6 LIMITING QUALITY PROTECTION. The sampling plans and associated procedures given in this publication were designed for use where the units of product are produced in a continuing series of lots or batches over a period of time. However, if the lot or batch is of an isolated nature, it is desirable to limit the selection of sampling plans to those, associated with a designated AQL value, that provide not less than a specified limiting quality protection. Sampling plans for this purpose can be selected by choosing a Limiting Quality (LQ) and a consumer's risk to be associated with it. Tables VI and VII give values of LQ for the commonly used consumer's risks of 10 percent and 5 percent respectively. If a different value of consumer's risk is required, the O.C. curves and their tabulated values may be used. The concept of LQ may also be useful in specifying the AQL and Inspection Levels for a series of lots or batches, thus fixing minimum sample size where there is some reason for avoiding (with more than a given consumer's risk) more than a limiting proportion of defectives (or defects) in any single lot or batch.

TABLE I — Sample size code letters

(See 9.2 and 9.3)

Lot or batch size			Special inspection levels				General inspection levels		
			S-1	S-2	S-3	S-4	I	II	III
2	to	8	A	A	A	A	A	A	B
9	to	15	A	A	A	A	A	B	C
16	to	25	A	A	B	B	B	C	D
26	to	50	A	B	B	C	C	D	E
51	to	90	B	B	C	C	C	E	F
91	to	150	B	B	C	D	D	F	G
151	to	280	B	C	D	E	E	G	H
281	to	500	B	C	D	E	F	H	J
501	to	1200	C	C	E	F	G	J	K
1201	to	3200	C	D	E	G	H	K	L
3201	to	10000	C	D	F	G	J	L	M
10001	to	35000	C	D	F	H	K	M	N
35001	to	150000	D	E	G	J	L	N	P
150001	to	500000	D	E	G	J	M	P	Q
500001	and	over	D	E	H	K	N	Q	R

CODE
LETTER

TABLE II-A—Single sampling plans for normal inspection (Master table)

(See 9.4 and 9.5)

Sample size code letter	Sample size	Acceptable Quality Levels (normal inspection)																									
		0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31
B	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45
C	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45	↑
D	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45	↑	↑
E	13	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45	↑	↑	↑
F	20	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑
G	32	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑
H	50	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑
J	80	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑
K	125	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
L	200	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
M	315	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
N	500	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
P	800	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
Q	1250	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
R	2000	↑	↑	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑

↓ = Use first sampling plan below arrow. If sample size equals, or exceeds, lot or batch size, do 100 percent inspection.

↑ = Use first sampling plan above arrow.

Ac = Acceptance number

Re = Rejection number

SINGLE
NORMAL

TABLE II-B—Single sampling plans for tightened inspection (Master table)

(See 9.4 and 9.5)

Sample size code letter	Sample size	Acceptable Quality Levels (tightened inspection) 0.010 Ac Re	0.015 Ac Re	0.025 Ac Re	0.040 Ac Re	0.065 Ac Re	0.10 Ac Re	0.15 Ac Re	0.25 Ac Re	0.40 Ac Re	0.65 Ac Re	1.0 Ac Re	1.5 Ac Re	2.5 Ac Re	4.0 Ac Re	6.5 Ac Re	10 Ac Re	15 Ac Re	25 Ac Re	40 Ac Re	65 Ac Re	100 Ac Re	150 Ac Re	250 Ac Re	400 Ac Re	650 Ac Re	1000 Ac Re
A	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	27 28
B	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	27 28	41 42
C	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	27 28	41 42	↑
D	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	27 28	41 42	↑	↑
E	13	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	27 28	41 42	↑	↑	↑
F	20	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑
G	32	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑
H	50	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑
J	80	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑
K	125	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
L	200	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
M	315	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
N	500	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
P	800	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
Q	1250	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
R	2000	0 1	↑	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
S	3150			1 2																							

↓ = Use first sampling plan below arrow. If sample size equals or exceeds lot or batch size, do 100 percent inspection.
↑ = Use first sampling plan above arrow.
Ac = Acceptance number.
Re = Rejection number.

SINGLE
TIGHTENED

TABLE II-C — *Single sampling plans for reduced inspection (Master table)*

(See 9.4 and 9.5)

Sample size code letter	Sample size	Acceptable Quality Levels (reduced inspection)† 0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31
B	2														0 1	↑		0 2	1 3	2 4	3 5	5 6	7 8	10 11	14 15	21 22	30 31
C	2													0 1	↑	↓	0 2	1 3	1 4	2 5	3 6	5 8	7 10	10 13	14 17	21 24	↑
D	3												0 1	↑	↓	0 2	1 3	1 4	2 5	3 6	5 8	7 10	10 13	14 17	21 24	↑	
E	5											0 1	↑	↓	0 2	1 3	1 4	2 5	3 6	5 8	7 10	10 13	14 17	21 24	↑		
F	8										0 1	↑	↓	0 2	1 3	1 4	2 5	3 6	5 8	7 10	10 13	↑	↑	↑			
G	13									0 1	↑	↓	0 2	1 3	1 4	2 5	3 6	5 8	7 10	10 13	↑						
H	20								0 1	↑	↓	0 2	1 3	1 4	2 5	3 6	5 8	7 10	10 13	↑							
J	32							0 1	↑	↓	0 2	1 3	1 4	2 5	3 6	5 8	7 10	10 13	↑								
K	50						0 1	↑	↓	0 2	1 3	1 4	2 5	3 6	5 8	7 10	10 13	↑									
L	80					0 1	↑	↓	0 2	1 3	1 4	2 5	3 6	5 8	7 10	10 13	↑										
M	125				0 1	↑	↓	0 2	1 3	1 4	2 5	3 6	5 8	7 10	10 13	↑											
N	200			0 1	↑	↓	0 2	1 3	1 4	2 5	3 6	5 8	7 10	10 13	↑												
P	315		0 1	↑	↓	0 2	1 3	1 4	2 5	3 6	5 8	7 10	10 13	↑													
Q	500	0 1	↑	↓	0 2	1 3	1 4	2 5	3 6	5 8	7 10	10 13	↑														
R	800	↑	↑	0 2	1 3	1 4	2 5	3 6	5 8	7 10	10 13	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑

↓ = Use first sampling plan below arrow. If sample size equals or exceeds lot or batch size, do 100 percent inspection.
↑ = Use first sampling plan above arrow.
Ac = Acceptance number.
Re = Rejection number.
† = If the acceptance number has been exceeded, but the rejection number has not been reached, accept the lot, but reinstate normal inspection (see 10.1.4).

SINGLE
REDUCED

TABLE III-A—Double sampling plans for normal inspection (Master table)

(See 9.4 and 9.5)

Sample size code letter	Sample	Sample size	Cumulative sample size	Acceptable Quality Levels (normal inspection)																									
				0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
				Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A				↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↓	↓	*	*	*	*	*	*	*	*	*
B	First	2	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	17 22	25 31
	Second	2	4																	1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27	37 38	56 57
C	First	3	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	17 22	25 31	↑
	Second	3	6																1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27	37 38	56 57	
D	First	5	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	17 22	25 31	↑	↑
	Second	5	10															1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27	37 38	56 57		
E	First	8	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	17 22	25 31	↑	↑	↑
	Second	8	16													1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27	37 38	56 57				
F	First	13	13	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑
	Second	13	26											1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27						
G	First	20	20	↓	↓	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑
	Second	20	40											1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27							
H	First	32	32	↓	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑	↑
	Second	32	64										1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27								
J	First	50	50	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	50	100									1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27									
K	First	80	80	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	80	160								1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27										
L	First	125	125	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	125	250							1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27											
M	First	200	200	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	200	400							1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27												
N	First	315	315	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	315	630						1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27													
P	First	500	500	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	500	1000					1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27														
Q	First	800	800	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	800	1600				1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27															
R	First	1250	1250	↑	↑	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	1250	2500			1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27																

↓ = Use first sampling plan below arrow. If sample size equals or exceeds lot or batch size, do 100 percent inspection.

↑ = Use first sampling plan above arrow.

Ac = Acceptance number

Re = Rejection number

* = Use corresponding single sampling plan (or alternatively, use double sampling plan below, where available).

DOUBLE
TIGHTENED

TABLE III-B — Double sampling plans for tightened inspection (Master table)

(See 9.4 and 9.5)

Sample size code letter	Sample	Sample size	Cumulative sample size	0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
				Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A				↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	*	*	*	*	*	*	*
B	First	2	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	15 20	23 29
	Second	2	4	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓		↓	↓	1 2	3 4	4 5	6 7	11 12	15 16	23 24	34 35	52 53
C	First	3	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	15 20	23 29	↑
	Second	3	6	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓		↓	↓	1 2	3 4	4 5	6 7	11 12	15 16	23 24	34 35	52 53	↑
D	First	5	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	15 20	23 29	↑	↑
	Second	5	10	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓		↓	↓	1 2	3 4	4 5	6 7	11 12	15 16	23 24	34 35	52 53	↑	↑
E	First	8	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	15 20	23 29	↑	↑	↑
	Second	8	16	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓		↓	↓	1 2	3 4	4 5	6 7	11 12	15 16	23 24	34 35	52 53	↑	↑	↑
F	First	13	13	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑
	Second	13	26	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓		↓	↓	1 2	3 4	4 5	6 7	11 12	15 16	23 24	↑	↑	↑	↑	↑	↑
G	First	20	20	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑
	Second	20	40	↓	↓	↓	↓	↓	↓	↓	↓	↓		↓	↓	1 2	3 4	4 5	6 7	11 12	15 16	23 24	↑	↑	↑	↑	↑	↑	↑
H	First	32	32	↓	↓	↓	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑	↑
	Second	32	64	↓	↓	↓	↓	↓	↓	↓	↓		↓	↓	1 2	3 4	4 5	6 7	11 12	15 16	23 24	↑	↑	↑	↑	↑	↑	↑	↑
J	First	50	50	↓	↓	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	50	100	↓	↓	↓	↓	↓	↓	↓		↓	↓	1 2	3 4	4 5	6 7	11 12	15 16	23 24	↑	↑	↑	↑	↑	↑	↑	↑	↑
K	First	80	80	↓	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	80	160	↓	↓	↓	↓	↓	↓		↓	↓	1 2	3 4	4 5	6 7	11 12	15 16	23 24	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
L	First	125	125	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	125	250	↓	↓	↓	↓	↓		↓	↓	1 2	3 4	4 5	6 7	11 12	15 16	23 24	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
M	First	200	200	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	200	400	↓	↓	↓	↓		↓	↓	1 2	3 4	4 5	6 7	11 12	15 16	23 24	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
N	First	315	315	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	315	630	↓	↓	↓		↓	↓	1 2	3 4	4 5	6 7	11 12	15 16	23 24	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
P	First	500	500	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	500	1000	↓	↓		↓	↓	1 2	3 4	4 5	6 7	11 12	15 16	23 24	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
Q	First	800	800	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	800	1600	↓		↓	↓	1 2	3 4	4 5	6 7	11 12	15 16	23 24	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
R	First	1250	1250	*	↑	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	1250	2500		↑	↓	1 2	3 4	4 5	6 7	11 12	15 16	23 24	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
S	First	2000	2000			0 2																							
	Second	2000	4000			1 2																							

↓ = Use first sampling plan below arrow. If sample size equals or exceeds lot or batch size, do 100 percent inspection.

↑ = Use first sampling plan above arrow.

Ac = Acceptance number

Re = Rejection number

* = Use corresponding single sampling plan (or, alternatively, use double sampling plan below, where available).

TABLE III-C — Double sampling plans for reduced inspection (Master table)

(See 9.4 and 9.5)

Sample size code letter	Sample	Sample size	Cumulative sample size	0.010 Ac Re	0.015 Ac Re	0.025 Ac Re	0.040 Ac Re	0.065 Ac Re	0.10 Ac Re	0.15 Ac Re	0.25 Ac Re	0.40 Ac Re	0.65 Ac Re	1.0 Ac Re	1.5 Ac Re	2.5 Ac Re	4.0 Ac Re	6.5 Ac Re	10 Ac Re	15 Ac Re	25 Ac Re	40 Ac Re	65 Ac Re	100 Ac Re	150 Ac Re	250 Ac Re	400 Ac Re	650 Ac Re	1000 Ac Re
				Acceptable Quality Levels (reduced inspection)†																									
A B C				↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓ •	↓ • ↑	• ↑ ↓	↓ • •	↓ • •	• • •	• • •	• • •	• • •	• • •	• • •	• • •	• • •	• • ↑
D	First Second	2 2	2 4	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	•	↑	↓	0 2 0 2	0 3 0 4	0 4 1 5	0 4 3 6	1 5 4 7	2 7 6 9	3 8 8 12	5 10 12 16	7 12 18 22	11 17 26 30	↑	↑
E	First Second	3 3	3 6	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	•	↑	↓	0 2 0 2	0 3 0 4	0 4 1 5	0 4 3 6	1 5 4 7	2 7 6 9	3 8 8 12	5 10 12 16	7 12 18 22	11 17 26 30	↑	↑	↑
F	First Second	5 5	5 10	↓	↓	↓	↓	↓	↓	↓	↓	↓	•	↑	↓	0 2 0 2	0 3 0 4	0 4 1 5	0 4 3 6	1 5 4 7	2 7 6 9	3 8 8 12	5 10 12 16	↑	↑	↑	↑	↑	↑
G	First Second	8 8	8 16	↓	↓	↓	↓	↓	↓	↓	↓	•	↑	↓	0 2 0 2	0 3 0 4	0 4 1 5	0 4 3 6	1 5 4 7	2 7 6 9	3 8 8 12	5 10 12 16	↑	↑	↑	↑	↑	↑	↑
H	First Second	13 13	13 26	↓	↓	↓	↓	↓	↓	↓	•	↑	↓	0 2 0 2	0 3 0 4	0 4 1 5	0 4 3 6	1 5 4 7	2 7 6 9	3 8 8 12	5 10 12 16	↑	↑	↑	↑	↑	↑	↑	↑
J	First Second	20 20	20 40	↓	↓	↓	↓	↓	↓	•	↑	↓	0 2 0 2	0 3 0 4	0 4 1 5	0 4 3 6	1 5 4 7	2 7 6 9	3 8 8 12	5 10 12 16	↑	↑	↑	↑	↑	↑	↑	↑	↑
K	First Second	32 32	32 64	↓	↓	↓	↓	↓	•	↑	↓	0 2 0 2	0 3 0 4	0 4 1 5	0 4 3 6	1 5 4 7	2 7 6 9	3 8 8 12	5 10 12 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
L	First Second	50 50	50 100	↓	↓	↓	↓	•	↑	↓	0 2 0 2	0 3 0 4	0 4 1 5	0 4 3 6	1 5 4 7	2 7 6 9	3 8 8 12	5 10 12 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
M	First Second	80 80	80 160	↓	↓	↓	•	↑	↓	0 2 0 2	0 3 0 4	0 4 1 5	0 4 3 6	1 5 4 7	2 7 6 9	3 8 8 12	5 10 12 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
N	First Second	125 125	125 250	↓	↓	•	↑	↓	0 2 0 2	0 3 0 4	0 4 1 5	0 4 3 6	1 5 4 7	2 7 6 9	3 8 8 12	5 10 12 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
P	First Second	200 200	200 400	↓	•	↑	↓	0 2 0 2	0 3 0 4	0 4 1 5	0 4 3 6	1 5 4 7	2 7 6 9	3 8 8 12	5 10 12 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
Q	First Second	315 315	315 630	•	↑	↓	0 2 0 2	0 3 0 4	0 4 1 5	0 4 3 6	1 5 4 7	2 7 6 9	3 8 8 12	5 10 12 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
R	First Second	500 500	500 1000	↑	↑	0 2 0 2	0 3 0 4	0 4 1 5	0 4 3 6	1 5 4 7	2 7 6 9	3 8 8 12	5 10 12 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑

↓ = Use first sampling plan below arrow. If sample size equals or exceeds lot or batch size, do 100 percent inspection.
↑ = Use first sampling plan above arrow.
Ac = Acceptance number
Re = Rejection number
• = Use corresponding single sampling plan (or alternatively, use double sampling plan below, when available.)
† = If, after the second sample, the acceptance number has been exceeded, but the rejection number has not been reached, accept the lot, but reinstate normal inspection (see 10.14).

DOUBLE REDUCED

MULTIPLE
NORMAL

TABLE IV-A—Multiple sampling plans for normal inspection (Master table)

(See 9.4 and 9.5)

Acceptable Quality Levels (normal inspection), each AQL column giving Ac Re

Sample size code letter	Sample	Sample size	Cumulative sample size	0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
A				↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	·	↓	↓	·	·	·	·	·	·	·	·	·
B				↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	·	↑	↓	++	++	++	++	++	++	++	++	++	++
C				↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	·	↑	↓	++	++	++	++	++	++	++	++	++	++	↑
D	First	2	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	·	↑	↓	* 2	* 2	* 3	* 4	0 4	0 5	1 7	2 9	4 12	6 16	↑	↑
	Second	2	4															* 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14	11 19	17 27		
	Third	2	6															0 2	0 3	1 4	2 6	3 8	6 10	8 13	13 19	19 27	29 39		
	Fourth	2	8															0 3	1 4	2 5	3 7	5 10	8 13	12 17	19 25	27 34	40 49		
	Fifth	2	10															1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29	36 40	53 58		
	Sixth	2	12															1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33	45 47	65 68		
	Seventh	2	14															2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38	53 54	77 78		
E	First	3	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	·	↑	↓	* 2	* 2	* 3	* 4	0 4	0 5	1 7	2 9	4 12	6 16	↑	↑	↑
	Second	3	6														* 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14	11 19	17 27			
	Third	3	9														0 2	0 3	1 4	2 6	3 8	6 10	8 13	13 19	19 27	29 39			
	Fourth	3	12														0 3	1 4	2 5	3 7	5 10	8 13	12 17	19 25	27 34	40 49			
	Fifth	3	15														1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29	36 40	53 58			
	Sixth	3	18														1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33	45 47	65 68			
	Seventh	3	21														2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38	53 54	77 78			
F	First	5	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	·	↑	↓	* 2	* 2	* 3	* 4	0 4	0 5	1 7	2 9	↑	↑	↑	↑	↑	↑
	Second	5	10													* 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14						
	Third	5	15													0 2	0 3	1 4	2 6	3 8	6 10	8 13	13 19						
	Fourth	5	20													0 3	1 4	2 5	3 7	5 10	8 13	12 17	19 25						
	Fifth	5	25													1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29						
	Sixth	5	30													1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33						
	Seventh	5	35													2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38						
G	First	8	8	↓	↓	↓	↓	↓	↓	↓	↓	·	↑	↓	* 2	* 2	* 3	* 4	0 4	0 5	1 7	2 9	↑	↑	↑	↑	↑	↑	↑
	Second	8	16											* 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14								
	Third	8	24											0 2	0 3	1 4	2 6	3 8	6 10	8 13	13 19								
	Fourth	8	32											0 3	1 4	2 5	3 7	5 10	8 13	12 17	19 25								
	Fifth	8	40											1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29								
	Sixth	8	48											1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33								
	Seventh	8	56											2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38								
H	First	13	13	↓	↓	↓	↓	↓	↓	↓	·	↑	↓	* 2	* 2	* 3	* 4	0 4	0 5	1 7	2 9	↑	↑	↑	↑	↑	↑	↑	↑
	Second	13	26											* 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14								
	Third	13	39											0 2	0 3	1 4	2 6	3 8	6 10	8 13	13 19								
	Fourth	13	52											0 3	1 4	2 5	3 7	5 10	8 13	12 17	19 25								
	Fifth	13	65											1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29								
	Sixth	13	78											1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33								
	Seventh	13	91											2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38								
J	First	20	20	↓	↓	↓	↓	↓	↓	·	↑	↓	* 2	* 2	* 3	* 4	0 4	0 5	1 7	2 9	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	20	40										* 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14									
	Third	20	60										0 2	0 3	1 4	2 6	3 8	6 10	8 13	13 19									
	Fourth	20	80										0 3	1 4	2 5	3 7	5 10	8 13	12 17	19 25									
	Fifth	20	100										1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29									
	Sixth	20	120										1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33									
	Seventh	20	140										2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38									

↓ = Use first sampling plan below arrow (refer to continuation of table on following page, when necessary). If sample size equals or exceeds lot or batch size, do 100 percent inspection.
↑ = Use first sampling plan above arrow
Ac = Acceptance number
Re = Rejection number
· = Use corresponding single sampling plan (or alternatively, use multiple sampling plan below, where available).
++ = Use corresponding double sampling plan (or alternatively, use multiple sampling plan below, where available).
* = Acceptance not permitted at this sample size.

TABLE IV-A — Multiple sampling plans for normal inspection (Master table)
(Continued)

(See 9.4 and 9.5)

Sample size code letter	Sample	Sample size	Cumulative sample size	Acceptable Quality Levels (normal inspection)																									
				0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
				Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
K	First	32	32	⇩	⇩	⇩	⇩	⇩	*	⇧	⇩	# 2	# 2	# 3	# 4	0 4	0 5	1 7	2 9	⇧	⇧	⇧	⇧	⇧	⇧	⇧	⇧	⇧	⇧
	Second	32	64									# 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14										
	Third	32	96									0 2	0 3	1 4	2 6	3 8	6 10	8 13	13 19										
	Fourth	32	128									0 3	1 4	2 5	3 7	5 10	8 13	12 17	19 25										
	Fifth	32	160									1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29										
	Sixth	32	192									1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33										
	Seventh	32	224									2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38										
L	First	50	50					*	⇧	⇩	# 2	# 2	# 3	# 4	0 4	0 5	1 7	2 9	⇧										
	Second	50	100								# 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14											
	Third	50	150								0 2	0 3	1 4	2 6	3 8	6 10	8 13	13 19											
	Fourth	50	200								0 3	1 4	2 5	3 7	5 10	8 13	12 17	19 25											
	Fifth	50	250								1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29											
	Sixth	50	300								1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33											
	Seventh	50	350								2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38											
M	First	80	80				*	⇧	⇩	# 2	# 2	# 3	# 4	0 4	0 5	1 7	2 9	⇧											
	Second	80	160							# 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14												
	Third	80	240							0 2	0 3	1 4	2 6	3 8	6 10	8 13	13 19												
	Fourth	80	320							0 3	1 4	2 5	3 7	5 10	8 13	12 17	19 25												
	Fifth	80	400							1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29												
	Sixth	80	480							1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33												
	Seventh	80	560							2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38												
N	First	125	125			*	⇧	⇩	# 2	# 2	# 3	# 4	0 4	0 5	1 7	2 9	⇧												
	Second	125	250						# 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14													
	Third	125	375						0 2	0 3	1 4	2 6	3 8	6 10	8 13	13 19													
	Fourth	125	500						0 3	1 4	2 5	3 7	5 10	8 13	12 17	19 25													
	Fifth	125	625						1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29													
	Sixth	125	750						1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33													
	Seventh	125	875						2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38													
P	First	200	200		*	⇧	⇩	# 2	# 2	# 3	# 4	0 4	0 5	1 7	2 9	⇧													
	Second	200	400					# 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14														
	Third	200	600					0 2	0 3	1 4	2 6	3 8	6 10	8 13	13 19														
	Fourth	200	800					0 3	1 4	2 5	3 7	5 10	8 13	12 17	19 25														
	Fifth	200	1000					1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29														
	Sixth	200	1200					1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33														
	Seventh	200	1400					2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38														
Q	First	315	315	*	⇧	⇩	# 2	# 2	# 3	# 4	0 4	0 5	1 7	2 9	⇧														
	Second	315	630				# 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14															
	Third	315	945				0 2	0 3	1 4	2 6	3 8	6 10	8 13	13 19															
	Fourth	315	1260				0 3	1 4	2 5	3 7	5 10	8 13	12 17	19 25															
	Fifth	315	1575				1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29															
	Sixth	315	1890				1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33															
	Seventh	315	2205				2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38															
R	First	500	500	⇧		# 2	# 2	# 3	# 4	0 4	0 5	1 7	2 9	⇧															
	Second	500	1000			# 2	0 3	0 3	1 5	1 6	3 8	4 10	7 14																
	Third	500	1500			0 2	0 3	1 4	2 6	3 8	6 10	8 13	13 19																
	Fourth	500	2000			0 3	1 4	2 5	3 7	5 10	8 13	12 17	19 25																
	Fifth	500	2500			1 3	2 4	3 6	5 8	7 11	11 15	17 20	25 29																
	Sixth	500	3000			1 3	3 5	4 6	7 9	10 12	14 17	21 23	31 33																
	Seventh	500	3500			2 3	4 5	6 7	9 10	13 14	18 19	25 26	37 38																

⇩ = Use first sampling plan below arrow. If sample size equals or exceeds lot or batch size, do 100 percent inspection.
⇧ = Use first sampling plan above arrow (refer to preceding page, when necessary).
Ac = Acceptance number
Re = Rejection number
* = Use corresponding single sampling plan (or alternatively, use multiple plan below, where available).
\# = Acceptance not permitted at this sample size.

MULTIPLE
NORMAL

TABLE IV-B—Multiple sampling plans for tightened inspection (Master table)

(See 9.4 and 9.5)

Sample size code letter	Sample	Sample size	Cumulative sample size	Acceptable Quality Levels (tightened inspection)																			
				0.010		0.015		0.025		0.040		0.065		0.10		0.15		0.25		0.40		0.65	
				Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re
A				↓		↓		↓		↓		↓		↓		↓		↓		↓		↓	
B				↓		↓		↓		↓		↓		↓		↓		↓		↓		↓	
C				↓		↓		↓		↓		↓		↓		↓		↓		↓		↓	
D	First	2	2	↓		↓		↓		↓		↓		↓		↓		↓		↓		↓	
	Second	2	4																				
	Third	2	6																				
	Fourth	2	8																				
	Fifth	2	10																				
	Sixth	2	12																				
	Seventh	2	14																				
E	First	3	3	↓		↓		↓		↓		↓		↓		↓		↓		↓		↓	
	Second	3	6																				
	Third	3	9																				
	Fourth	3	12																				
	Fifth	3	15																				
	Sixth	3	18																				
	Seventh	3	21																				
F	First	5	5	↓		↓		↓		↓		↓		↓		↓		↓		↓		↓	
	Second	5	10																				
	Third	5	15																				
	Fourth	5	20																				
	Fifth	5	25																				
	Sixth	5	30																				
	Seventh	5	35																				
G	First	8	8	↓		↓		↓		↓		↓		↓		↓		↓		↓		*	
	Second	8	16																				
	Third	8	24																				
	Fourth	8	32																				
	Fifth	8	40																				
	Sixth	8	48																				
	Seventh	8	56																				
H	First	13	13	↓		↓		↓		↓		↓		↓		↓		↓		*		↓	
	Second	13	26																				
	Third	13	39																				
	Fourth	13	52																				
	Fifth	13	65																				
	Sixth	13	78																				
	Seventh	13	91																				
J	First	20	20	↓		↓		↓		↓		↓		↓		↓		*		↓		↓	
	Second	20	40																				
	Third	20	60																				
	Fourth	20	80																				
	Fifth	20	100																				
	Sixth	20	120																				
	Seventh	20	140																				

Sample size code letter	Sample	Sample size	Cumulative sample size	1.0		1.5		2.5		4.0		6.5		10	
				Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re
A				↓		↓		↓		↓		↓		↓	
B				↓		↓		↓		↓		*		↓	
C				↓		↓		↓		*		↓		↓	
D	First	2	2	↓		↓		*		↓		↓		#	2
	Second	2	4											#	2
	Third	2	6											0	2
	Fourth	2	8											0	3
	Fifth	2	10											1	3
	Sixth	2	12											1	3
	Seventh	2	14											2	3
E	First	3	3	↓		*		↓		↓		#	2	#	2
	Second	3	6									#	2	0	3
	Third	3	9									0	2	0	3
	Fourth	3	12									0	3	1	4
	Fifth	3	15									1	3	2	4
	Sixth	3	18									1	3	3	5
	Seventh	3	21									2	3	4	5
F	First	5	5	*		↓		↓		#	2	#	2	#	3
	Second	5	10							#	2	0	3	0	3
	Third	5	15							0	2	0	3	1	4
	Fourth	5	20							0	3	1	4	2	5
	Fifth	5	25							1	3	2	4	3	6
	Sixth	5	30							1	3	3	5	4	6
	Seventh	5	35							2	3	4	5	6	7
G	First	8	8	↓		↓		#	2	#	2	#	3	#	4
	Second	8	16					#	2	0	3	0	3	1	5
	Third	8	24					0	2	0	3	1	4	2	6
	Fourth	8	32					0	3	1	4	2	5	3	7
	Fifth	8	40					1	3	2	4	3	6	5	8
	Sixth	8	48					1	3	3	5	4	6	7	9
	Seventh	8	56					2	3	4	5	6	7	9	10
H	First	13	13	↓		#	2	#	2	#	3	#	4	0	4
	Second	13	26			#	2	0	3	0	3	1	5	2	7
	Third	13	39			0	2	0	3	1	4	7	6	4	9
	Fourth	13	52			0	3	1	4	2	5	3	7	6	11
	Fifth	13	65			1	3	2	4	3	6	5	8	9	12
	Sixth	13	78			1	3	3	5	4	6	7	9	12	14
	Seventh	13	91			2	3	4	5	6	7	9	10	14	15
J	First	20	20	#	2	#	2	#	3	#	4	0	4	0	6
	Second	20	40	#	2	0	3	0	3	1	5	2	7	3	9
	Third	20	60	0	2	0	3	1	4	2	6	4	9	7	12
	Fourth	20	80	0	3	1	4	2	5	3	7	6	11	10	15
	Fifth	20	100	1	3	2	4	3	6	5	8	9	12	14	17
	Sixth	20	120	1	3	3	5	4	6	7	9	12	14	18	20
	Seventh	20	140	2	3	4	5	6	7	9	10	14	15	21	22

Sample size code letter	Sample	Sample size	Cumulative sample size	15		25		40		65		100		150		250		400		650		1000	
				Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re
A				↓		↓		*		*		*		*		*		*		*		*	
B				↓		++		++		++		++		++		++		++		++		++	
C				++		++		++		++		++		++		++		++		++		↑	
D	First	2	2	#	2	#	3	#	4	0	4	0	6	1	8	3	10	6	15	↑		↑	
	Second	2	4	0	3	0	3	1	5	2	7	3	9	6	12	10	17	16	25				
	Third	2	6	0	3	1	4	2	6	4	9	7	12	11	17	17	24	26	36				
	Fourth	2	8	1	4	2	5	3	7	6	11	10	15	16	22	24	31	37	46				
	Fifth	2	10	2	4	3	6	5	8	9	12	14	17	22	25	32	37	49	55				
	Sixth	2	12	3	5	4	6	7	9	12	14	18	20	27	29	40	43	61	64				
	Seventh	2	14	4	5	6	7	9	10	14	15	21	22	32	33	48	49	72	73				
E	First	3	3	#	3	#	4	0	4	0	6	1	8	3	10	6	15	↑		↑		↑	
	Second	3	6	0	3	1	5	2	7	3	9	6	12	10	17	16	25						
	Third	3	9	1	4	2	6	4	9	7	12	11	17	17	24	26	36						
	Fourth	3	12	2	5	3	7	6	11	10	15	16	22	24	31	37	46						
	Fifth	3	15	3	6	5	8	9	12	14	17	22	25	32	37	49	55						
	Sixth	3	18	4	6	7	9	12	14	18	20	27	29	40	43	61	64						
	Seventh	3	21	6	7	9	10	14	15	21	22	32	33	48	49	72	73						
F	First	5	5	#	4	0	4	0	6	1	8	↑		↑		↑		↑		↑		↑	
	Second	5	10	1	5	2	7	3	9	6	12												
	Third	5	15	2	6	4	9	7	12	11	17												
	Fourth	5	20	3	7	6	11	10	15	16	22												
	Fifth	5	25	5	8	9	12	14	17	22	25												
	Sixth	5	30	7	9	12	14	18	20	27	29												
	Seventh	5	35	9	10	14	15	21	22	32	33												
G	First	8	8	0	4	0	6	1	8	↑		↑		↑		↑		↑		↑		↑	
	Second	8	16	2	7	3	9	6	12														
	Third	8	24	4	9	7	12	11	17														
	Fourth	8	32	6	11	10	15	16	22														
	Fifth	8	40	9	12	14	17	22	25														
	Sixth	8	48	12	14	18	20	27	29														
	Seventh	8	56	14	15	21	22	32	33														
H	First	13	13	0	6	1	8	↑		↑		↑		↑		↑		↑		↑		↑	
	Second	13	26	3	9	6	12																
	Third	13	39	7	12	11	17																
	Fourth	13	52	10	15	16	22																
	Fifth	13	65	14	17	22	25																
	Sixth	13	78	18	20	27	29																
	Seventh	13	91	21	22	32	33																
J	First	20	20	1	8	↑		↑		↑		↑		↑		↑		↑		↑		↑	
	Second	20	40	6	12																		
	Third	20	60	11	17																		
	Fourth	20	80	16	22																		
	Fifth	20	100	22	25																		
	Sixth	20	120	27	29																		
	Seventh	20	140	32	33																		

↓ = Use first sampling plan below arrow (refer to continuation of table on following page, when necessary). If sample size equals or exceeds lot or batch size, do 100 percent inspection.
↑ = Use first sampling plan above arrow
Ac = Acceptance number
Re = Rejection number
* = Use corresponding single sampling plan (or alternatively, use multiple sampling plan below, where available)
++ = Use corresponding double sampling plan (or alternatively, use multiple sampling plan below, where available)
\# = Acceptance not permitted at this sample size

MULTIPLE
TIGHTENED

TABLE IV-B — Multiple sampling plans for tightened inspection (Master table) (Continued)

(See 9.4 and 9.5)

Acceptable Quality Levels (tightened inspection)

Sample size code letter	Sample	Sample size	Cumulative sample size	0.010 Ac Re	0.015 Ac Re	0.025 Ac Re	0.040 Ac Re	0.065 Ac Re	0.10 Ac Re	0.15 Ac Re	0.25 Ac Re	0.40 Ac Re	0.65 Ac Re	1.0 Ac Re	1.5 Ac Re	2.5 Ac Re	4.0 Ac Re	6.5 Ac Re	10 Ac Re	15 Ac Re	25 Ac Re	40 Ac Re	65 Ac Re	100 Ac Re	150 Ac Re	250 Ac Re	400 Ac Re	650 Ac Re	1000 Ac Re
K	First	32	32	↓	↓	↓	↓	↓	↓	*	↓	↓	# 2	# 2	# 3	# 4	0 4	0 6	1 8	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	32	64										# 2	0 3	0 3	1 5	2 7	3 9	6 12										
	Third	32	96										0 2	0 3	1 4	2 6	4 9	7 12	11 17										
	Fourth	32	128										0 3	1 4	2 5	3 7	6 11	10 15	16 22										
	Fifth	32	160										1 3	2 4	3 6	5 8	9 12	14 17	22 25										
	Sixth	32	192										1 3	3 5	4 6	7 9	12 14	18 20	27 29										
	Seventh	32	224										2 3	4 5	6 7	9 10	14 15	21 22	32 33										
L	First	50	50	↓	↓	↓	↓	↓	*	↓	↓	# 2	# 2	# 3	# 4	0 4	0 6	1 8	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	50	100									# 2	0 3	0 3	1 5	2 7	3 9	6 12											
	Third	50	150									0 2	0 3	1 4	2 6	4 9	7 12	11 17											
	Fourth	50	200									0 3	1 4	2 5	3 7	6 11	10 15	16 22											
	Fifth	50	250									1 3	2 4	3 6	5 8	9 12	14 17	22 25											
	Sixth	50	300									1 3	3 5	4 6	7 9	12 14	18 20	27 29											
	Seventh	50	350									2 3	4 5	6 7	9 10	14 15	21 22	32 33											
M	First	80	80	↓	↓	↓	↓	*	↓	↓	# 2	# 2	# 3	# 4	0 4	0 6	1 8	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	80	160								# 2	0 3	0 3	1 5	2 7	3 9	6 12												
	Third	80	240								0 2	0 3	1 4	2 6	4 9	7 12	11 17												
	Fourth	80	320								0 3	1 4	2 5	3 7	6 11	10 15	16 22												
	Fifth	80	400								1 3	2 4	3 6	5 8	9 12	14 17	22 25												
	Sixth	80	480								1 3	3 5	4 6	7 9	12 14	18 20	27 29												
	Seventh	80	560								2 3	4 5	6 7	9 10	14 15	21 22	32 33												
N	First	125	125	↓	↓	↓	*	↓	↓	# 2	# 2	# 3	# 4	0 4	0 6	1 8	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	125	250							# 2	0 3	0 3	1 5	2 7	3 9	6 12													
	Third	125	375							0 2	0 3	1 4	2 6	4 9	7 12	11 17													
	Fourth	125	500							0 3	1 4	2 5	3 7	6 11	10 15	16 22													
	Fifth	125	625							1 3	2 4	3 6	5 8	9 12	14 17	22 25													
	Sixth	125	750							1 3	3 5	4 6	7 9	12 14	18 20	27 29													
	Seventh	125	875							2 3	4 5	6 7	9 10	14 15	21 22	32 33													
P	First	200	200	↓	↓	*	↓	↓	# 2	# 2	# 3	# 4	0 4	0 6	1 8	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	200	400						# 2	0 3	0 3	1 5	2 7	3 9	6 12														
	Third	200	600						0 2	0 3	1 4	2 6	4 9	7 12	11 17														
	Fourth	200	800						0 3	1 4	2 5	3 7	6 11	10 15	16 22														
	Fifth	200	1000						1 3	2 4	3 6	5 8	9 12	14 17	22 25														
	Sixth	200	1200						1 3	3 5	4 6	7 9	12 14	18 20	27 29														
	Seventh	200	1400						2 3	4 5	6 7	9 10	14 15	21 22	32 33														
Q	First	315	315	↓	*	↓	↓	# 2	# 2	# 3	# 4	0 4	0 6	1 8	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	315	630					# 2	0 3	0 3	1 5	2 7	3 9	6 12															
	Third	315	945					0 2	0 3	1 4	2 6	4 9	7 12	11 17															
	Fourth	315	1260					0 3	1 4	2 5	3 7	6 11	10 15	16 22															
	Fifth	315	1575					1 3	2 4	3 6	5 8	9 12	14 17	22 25															
	Sixth	315	1890					1 3	3 5	4 6	7 9	12 14	18 20	27 29															
	Seventh	315	2205					2 3	4 5	6 7	9 10	14 15	21 22	32 33															
R	First	500	500	*	↑	↓	# 2	# 2	# 3	# 4	0 4	0 6	1 8	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	500	1000				# 2	0 3	0 3	1 5	2 7	3 9	6 12																
	Third	500	1500				0 2	0 3	1 4	2 6	4 9	7 12	11 17																
	Fourth	500	2000				0 3	1 4	2 5	3 7	6 11	10 15	16 22																
	Fifth	500	2500				1 3	2 4	3 6	5 8	9 12	14 17	22 25																
	Sixth	500	3000				1 3	3 5	4 6	7 9	12 14	18 20	27 29																
	Seventh	500	3500				2 3	4 5	6 7	9 10	14 15	21 22	32 33																
S	First	800	800			# 2																							
	Second	800	1600			# 2																							
	Third	800	2400			0 2																							
	Fourth	800	3200			0 3																							
	Fifth	800	4000			1 3																							
	Sixth	800	4800			1 3																							
	Seventh	800	5600			2 3																							

⇩ = Use first sampling plan below arrow. If sample size equals or exceeds lot or batch size, do 100 percent inspection.
⇧ = Use first sampling plan above arrow (refer to preceding page, when necessary).
Ac = Acceptance number.
Re = Rejection number.
* = Use corresponding single sampling plan (or alternatively, use multiple sampling plan below, where available).
# = Acceptance not permitted at this sample size.

TABLE IV-C—Multiple sampling plans for reduced inspection (Master table)

(See 9.4 and 9.5)

Sample size code letter	Sample	Sample size	Cumulative sample size	Acceptable Quality Levels (reduced inspection) †																									
				0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
				Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A				↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	•	↓	↓	•	•	•	•	•	•	•	•	•
B				↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	•	↑	↓	•	•	•	•	•	•	•	•	•	•
C				↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	•	↑	↓	•	•	•	•	•	•	•	•	•	•	↑
D				↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	•	↑	↓	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↑	↑
E				↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	•	↑	↓	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↑	↑	↑
F	First	2	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	•	↑	↓	* 2	* 2	* 3	* 3	* 4	* 4	0 5	0 6	↑	↑	↑	↑	↑	↑
	Second	2	4	↓	↓	↓	↓	↓	↓	↓	↓	↓		↑	↓	* 2	* 3	* 3	0 4	0 5	1 6	1 7	3 9	↑	↑	↑	↑	↑	↑
	Third	2	6	↓	↓	↓	↓	↓	↓	↓	↓	↓		↑	↓	0 2	0 3	0 4	0 5	1 6	2 8	3 9	6 12	↑	↑	↑	↑	↑	↑
	Fourth	2	8	↓	↓	↓	↓	↓	↓	↓	↓	↓		↑	↓	0 3	0 4	0 5	1 6	2 7	3 10	5 12	8 15	↑	↑	↑	↑	↑	↑
	Fifth	2	10	↓	↓	↓	↓	↓	↓	↓	↓	↓		↑	↓	0 3	0 4	1 6	2 7	3 8	5 11	7 13	11 17	↑	↑	↑	↑	↑	↑
	Sixth	2	12	↓	↓	↓	↓	↓	↓	↓	↓	↓		↑	↓	0 3	1 5	1 6	3 7	4 9	7 12	10 15	14 20	↑	↑	↑	↑	↑	↑
	Seventh	2	14	↓	↓	↓	↓	↓	↓	↓	↓	↓		↑	↓	1 3	1 5	2 7	4 8	6 10	9 14	13 17	18 22	↑	↑	↑	↑	↑	↑
G	First	3	3	↓	↓	↓	↓	↓	↓	↓	↓	•	↑	↓	* 2	* 2	* 3	* 3	* 4	* 4	0 5	0 6	↑	↑	↑	↑	↑	↑	↑
	Second	3	6	↓	↓	↓	↓	↓	↓	↓	↓		↑	↓	* 2	* 3	* 3	0 4	0 5	1 6	1 7	3 9	↑	↑	↑	↑	↑	↑	↑
	Third	3	9	↓	↓	↓	↓	↓	↓	↓	↓		↑	↓	0 2	0 3	0 4	0 5	1 6	2 8	3 9	6 12	↑	↑	↑	↑	↑	↑	↑
	Fourth	3	12	↓	↓	↓	↓	↓	↓	↓	↓		↑	↓	0 3	0 4	0 5	1 6	2 7	3 10	5 12	8 15	↑	↑	↑	↑	↑	↑	↑
	Fifth	3	15	↓	↓	↓	↓	↓	↓	↓	↓		↑	↓	0 3	0 4	1 6	2 7	3 8	5 11	7 13	11 17	↑	↑	↑	↑	↑	↑	↑
	Sixth	3	18	↓	↓	↓	↓	↓	↓	↓	↓		↑	↓	0 3	1 5	1 6	3 7	4 9	7 12	10 15	14 20	↑	↑	↑	↑	↑	↑	↑
	Seventh	3	21	↓	↓	↓	↓	↓	↓	↓	↓		↑	↓	1 3	1 5	2 7	4 8	6 10	9 14	13 17	18 22	↑	↑	↑	↑	↑	↑	↑
H	First	5	5	↓	↓	↓	↓	↓	↓	↓	•	↑	↓	* 2	* 2	* 3	* 3	* 4	* 4	0 5	0 6	↑	↑	↑	↑	↑	↑	↑	↑
	Second	5	10	↓	↓	↓	↓	↓	↓	↓		↑	↓	* 2	* 3	* 3	0 4	0 5	1 6	1 7	3 9	↑	↑	↑	↑	↑	↑	↑	↑
	Third	5	15	↓	↓	↓	↓	↓	↓	↓		↑	↓	0 2	0 3	0 4	0 5	1 6	2 8	3 9	6 12	↑	↑	↑	↑	↑	↑	↑	↑
	Fourth	5	20	↓	↓	↓	↓	↓	↓	↓		↑	↓	0 3	0 4	0 5	1 6	2 7	3 10	5 12	8 15	↑	↑	↑	↑	↑	↑	↑	↑
	Fifth	5	25	↓	↓	↓	↓	↓	↓	↓		↑	↓	0 3	0 4	1 6	2 7	3 8	5 11	7 13	11 17	↑	↑	↑	↑	↑	↑	↑	↑
	Sixth	5	30	↓	↓	↓	↓	↓	↓	↓		↑	↓	0 3	1 5	1 6	3 7	4 9	7 12	10 15	14 20	↑	↑	↑	↑	↑	↑	↑	↑
	Seventh	5	35	↓	↓	↓	↓	↓	↓	↓		↑	↓	1 3	1 5	2 7	4 8	6 10	9 14	13 17	18 22	↑	↑	↑	↑	↑	↑	↑	↑
J	First	8	8	↓	↓	↓	↓	↓	↓	•	↑	↓	* 2	* 2	* 3	* 3	* 4	* 4	0 5	0 6	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	8	16	↓	↓	↓	↓	↓	↓		↑	↓	* 2	* 3	* 3	0 4	0 5	1 6	1 7	3 9	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Third	8	24	↓	↓	↓	↓	↓	↓		↑	↓	0 2	0 3	0 4	0 5	1 6	2 8	3 9	6 12	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Fourth	8	32	↓	↓	↓	↓	↓	↓		↑	↓	0 3	0 4	0 5	1 6	2 7	3 10	5 12	8 15	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Fifth	8	40	↓	↓	↓	↓	↓	↓		↑	↓	0 3	0 4	1 6	2 7	3 8	5 11	7 13	11 17	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Sixth	8	48	↓	↓	↓	↓	↓	↓		↑	↓	0 3	1 5	1 6	3 7	4 9	7 12	10 15	14 20	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Seventh	8	56	↓	↓	↓	↓	↓	↓		↑	↓	1 3	1 5	2 7	4 8	6 10	9 14	13 17	18 22	↑	↑	↑	↑	↑	↑	↑	↑	↑
K	First	13	13	↓	↓	↓	↓	↓	•	↑	↓	* 2	* 2	* 3	* 3	* 4	* 4	0 5	0 6	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	13	26	↓	↓	↓	↓	↓		↑	↓	* 2	* 3	* 3	0 4	0 5	1 6	1 7	3 9	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Third	13	39	↓	↓	↓	↓	↓		↑	↓	0 2	0 3	0 4	0 5	1 6	2 8	3 9	6 12	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Fourth	13	52	↓	↓	↓	↓	↓		↑	↓	0 3	0 4	0 5	1 6	2 7	3 10	5 12	8 15	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Fifth	13	65	↓	↓	↓	↓	↓		↑	↓	0 3	0 4	1 6	2 7	3 8	5 11	7 13	11 17	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Sixth	13	78	↓	↓	↓	↓	↓		↑	↓	0 3	1 5	1 6	3 7	4 9	7 12	10 15	14 20	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Seventh	13	91	↓	↓	↓	↓	↓		↑	↓	1 3	1 5	2 7	4 8	6 10	9 14	13 17	18 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑

⇩ = Use first sampling plan below arrow (refer to continuation of table on following page, when necessary). If sample size equals, or exceeds lot or batch size, do 100 percent inspection

⇧ = Use first sampling plan above arrow

Ac = Acceptance number

Re = Rejection number

• = Use corresponding single sampling plan (or alternatively, use multiple sampling plan below, where available)

↔ = Use corresponding double sampling plan (or alternatively, use multiple sampling plan below, where available)

* = Acceptance not permitted at this sample size

† = If, after the final sample, the acceptance number has been exceeded, but the rejection number has not been reached, accept the lot but reinstate normal inspection (see 10.1.4)

MULTIPLE
REDUCED

TABLE IV-C — *Multiple sampling plans for reduced inspection (Master table)* (*Continued*)

(*See 9.4 and 9.5*)

Sample size code letter	Sample	Sample size	Cumulative sample size	Acceptable Quality Levels (reduced inspection)†																									
				0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
				Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
L	First	20	20	↓	↓	↓	↓	*	↑	↓	* 2	* 2	* 3	* 3	* 4	* 4	0 5	0 6	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	20	40								* 2	* 3	* 3	0 4	0 5	1 6	1 7	3 9											
	Third	20	60								0 2	0 3	0 4	0 5	1 6	2 8	3 9	6 12											
	Fourth	20	80								0 3	0 4	0 5	1 6	2 7	3 10	5 12	8 15											
	Fifth	20	100								0 3	0 4	1 6	2 7	3 8	5 11	7 13	11 17											
	Sixth	20	120								0 3	1 5	1 6	3 7	4 9	7 12	10 15	14 20											
	Seventh	20	140								1 3	1 5	2 7	4 8	6 10	9 14	13 17	18 22											
M	First	32	32				*	↑	↓	* 2	* 2	* 3	* 3	* 4	* 4	0 5	0 6	↑											
	Second	32	64							* 2	* 3	* 3	0 4	0 5	1 6	1 7	3 9												
	Third	32	96							0 2	0 3	0 4	0 5	1 6	2 8	3 9	6 12												
	Fourth	32	128							0 3	0 4	0 5	1 6	2 7	3 10	5 12	8 15												
	Fifth	32	160							0 3	0 4	1 6	2 7	3 8	5 11	7 13	11 17												
	Sixth	32	192							0 3	1 5	1 6	3 7	4 9	7 12	10 15	14 20												
	Seventh	32	224							1 3	1 5	2 7	4 8	6 10	9 14	13 17	18 22												
N	First	50	50			*	↑	↓	* 2	* 2	* 3	* 3	* 4	* 4	0 5	0 6	↑												
	Second	50	100						* 2	* 3	* 3	0 4	0 5	1 6	1 7	3 9													
	Third	50	150						0 2	0 3	0 4	0 5	1 6	2 8	3 9	6 12													
	Fourth	50	200						0 3	0 4	0 5	1 6	2 7	3 10	5 12	8 15													
	Fifth	50	250						0 3	0 4	1 6	2 7	3 8	5 11	7 13	11 17													
	Sixth	50	300						0 3	1 5	1 6	3 7	4 9	7 12	10 15	14 20													
	Seventh	50	350						1 3	1 5	2 7	4 8	6 10	9 14	13 17	18 22													
P	First	80	80		*	↑	↓	* 2	* 2	* 3	* 3	* 4	* 4	0 5	0 6	↑													
	Second	80	160					* 2	* 3	* 3	0 4	0 5	1 6	1 7	3 9														
	Third	80	240					0 2	0 3	0 4	0 5	1 6	2 8	3 9	6 12														
	Fourth	80	320					0 3	0 4	0 5	1 6	2 7	3 10	5 12	8 15														
	Fifth	80	400					0 3	0 4	1 6	2 7	3 8	5 11	7 13	11 17														
	Sixth	80	480					0 3	1 5	1 6	3 7	4 9	7 12	10 15	14 20														
	Seventh	80	560					1 3	1 5	2 7	4 8	6 10	9 14	13 17	18 22														
Q	First	125	125	*	↑	↓	* 2	* 2	* 3	* 3	* 4	* 4	0 5	0 6	↑														
	Second	125	250				* 2	* 3	* 3	0 4	0 5	1 6	1 7	3 9															
	Third	125	375				0 2	0 3	0 4	0 5	1 6	2 8	3 9	6 12															
	Fourth	125	500				0 3	0 4	0 5	1 6	2 7	3 10	5 12	8 15															
	Fifth	125	625				0 3	0 4	1 6	2 7	3 8	5 11	7 13	11 17															
	Sixth	125	750				0 3	1 5	1 6	3 7	4 9	7 12	10 15	14 20															
	Seventh	125	875				1 3	1 5	2 7	4 8	6 10	9 14	13 17	18 22															
R	First	200	200	↑		* 2	* 2	* 3	* 3	* 4	* 4	0 5	0 6	↑															
	Second	200	400			* 2	* 3	* 3	0 4	0 5	1 6	1 7	3 9																
	Third	200	600			0 2	0 3	0 4	0 5	1 6	2 8	3 9	6 12																
	Fourth	200	800			0 3	0 4	0 5	1 6	2 7	3 10	5 12	8 15																
	Fifth	200	1000			0 3	0 4	1 6	2 7	3 8	5 11	7 13	11 17																
	Sixth	200	1200			0 3	1 5	1 6	3 7	4 9	7 12	10 15	14 20																
	Seventh	200	1400			1 3	1 5	2 7	4 8	6 10	9 14	13 17	18 22																

↓ = Use first sampling plan below arrow. If sample size equals, or exceeds, lot or batch size, do 100 percent inspection

↑ = Use first sampling plan above arrow (refer to preceding page when necessary)

Ac = Acceptance number

Re = Rejection number

* = Acceptance not permitted at this sample size

† = If, after the final sample, the acceptance number has been exceeded, but the rejection number has not been reached, accept the lot, but reinstate normal inspection (see 10.1.4)

MULTIPLE REDUCED

TABLE V-A — *Average Outgoing Quality Limit Factors for Normal Inspection (Single sampling)*

(See 11.4)

Code Letter	Sample Size	Acceptable Quality Level																									
		0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
A	2															18			42	69	97	160	220	330	470	730	1100
B	3														12			28	46	65	110	150	220	310	490	720	1100
C	5													7.4			17	27	39	63	90	130	190	290	430	660	
D	8												4.6			11	17	24	40	56	82	120	180	270	410		
E	13											2.8			6.5	11	15	24	34	50	72	110	170	250			
F	20										1.8			4.2	6.9	9.7	16	22	33	47	73						
G	32									1.2			2.6	4.3	6.1	9.9	14	21	29	46							
H	50								0.74			1.7	2.7	3.9	6.3	9.0	13	19	29								
J	80							0.46			1.1	1.7	2.4	4.0	5.6	8.2	12	18									
K	125						0.29			0.67	1.1	1.6	2.5	3.6	5.2	7.5	12										
L	200					0.18			0.42	0.69	0.97	1.6	2.2	3.3	4.7	7.3											
M	315				0.12			0.27	0.44	0.62	1.00	1.4	2.1	3.0	4.7												
N	500			0.074			0.17	0.27	0.39	0.63	0.90	1.3	1.9	2.9													
P	800		0.046			0.11	0.17	0.24	0.40	0.56	0.82	1.2	1.8														
Q	1250	0.029			0.067	0.11	0.16	0.25	0.36	0.52	0.75	1.2															
R	2000			0.042	0.069	0.097	0.16	0.22	0.33	0.47	0.73																

Note: For the exact AOQL, the above values must be multiplied by $\left(1 - \frac{\text{Sample size}}{\text{Lot or Batch size}}\right)$ (see 11.4)

AOQL
NORMAL

TABLE V-B — *Average Outgoing Quality Limit Factors for Tightened Inspection (Single sampling)*

(See 11.4)

Code letter	Sample size	Acceptable Quality Level 0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
A	2																			42	69	97	160	260	400	620	970
B	3															12			28	46	65	110	170	270	410	650	1100
C	5														7.4			17	27	39	63	100	160	250	390	610	
D	8													4.6			11	17	24	40	64	99	160	240	380		
E	13												2.8			6.5	11	15	24	40	61	95	150	240			
F	20											1.8			4.2	6.9	9.7	16	26	40	62						
G	32										1.2			2.6	4.3	6.1	9.9	16	25	39							
H	50									0.74			1.7	2.7	3.9	6.3	10	16	25								
J	80								0.46			1.1	1.7	2.4	4.0	6.4	9.9	16									
K	125							0.29			0.67	1.1	1.6	2.5	4.1	6.4	9.9										
L	200						0.18			0.42	0.69	0.97	1.6	2.6	4.0	6.2											
M	315					0.12			0.27	0.44	0.62	1.0	1.6	2.5	3.9												
N	500				0.074			0.17	0.27	0.39	0.63	1.0	1.6	2.5													
P	800			0.046			0.11	0.17	0.24	0.40	0.64	0.99	1.6														
Q	1250		0.029			0.067	0.11	0.16	0.25	0.41	0.64	0.99															
[illegible]	2000	0.018			0.042	0.069	0.097	0.16	0.26	0.40	0.62																
[illegible]	3150			0.027																							

Note: For the exact AOQL, the above values must be multiplied by $\left(1 - \frac{\text{Sample size}}{\text{Lot or Batch size}}\right)$ (see 11.4)

AOQL
TIGHTENED

*TABLE VI-A — **Limiting Quality** (in percent defective) for which P_a = 10 Percent*
(for Normal Inspection, Single sampling)

(See 11.6)

Code letter	Sample size	Acceptable Quality Level															
		0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10
A	2															68	
B	3														54		
C	5													37			58
D	8												25			41	54
E	13											16			27	36	44
F	20										11			18	25	30	42
G	32									6.9			12	16	20	27	34
H	50								4.5			7.6	10	13	18	22	29
J	80							2.8			4.8	6.5	8.2	11	14	19	24
K	125						1.8			3.1	4.3	5.4	7.4	9.4	12	16	23
L	200					1.2			2.0	2.7	3.3	4.6	5.9	7.7	10	14	
M	315				0.73			1.2	1.7	2.1	2.9	3.7	4.9	6.4	9.0		
N	500			0.46			0.78	1.1	1.3	1.9	2.4	3.1	4.0	5.6			
P	800		0.29			0.49	0.67	0.84	1.2	1.5	1.9	2.5	3.5				
Q	1250	0.18			0.31	0.43	0.53	0.74	0.94	1.2	1.6	2.3					
R	2000			0.20	0.27	0.33	0.46	0.59	0.77	1.0	1.4						

LQ (DEFECTIVES)
10.0%

TABLE VI-B—Limiting Quality (in defects per hundred units) for which P_a = 10 Percent
(for Normal Inspection, Single sampling)

(See 11.6)

Code letter	Sample size	Acceptable Quality Level																									
		0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
A	2															120			200	270	330	460	590	770	1000	1400	1900
B	3														77			130	180	220	310	390	510	670	940	1300	1800
C	5													46			78	110	130	190	240	310	400	560	770	1100	
D	8												29			49	67	84	120	150	190	250	350	480	670		
E	13											18			30	41	51	71	91	120	160	220	300	410			
F	20										12			20	27	33	46	59	77	100	140						
G	32									7.2			12	17	21	29	37	48	63	88							
H	50								4.6			7.8	11	13	19	24	31	40	56								
J	80							2.9			4.9	6.7	8.4	12	15	19	25	35									
K	125						1.8			3.1	4.3	5.4	7.4	9.4	12	16	23										
L	200					1.2			2.0	2.7	3.3	4.6	5.9	7.7	10	14											
M	315				0.73			1.2	1.7	2.1	2.9	3.7	4.9	6.4	9.0												
N	500			0.46			0.78	1.1	1.3	1.9	2.4	3.1	4.0	5.6													
P	800		0.29			0.49	0.67	0.84	1.2	1.5	1.9	2.5	3.5														
Q	1250	0.18			0.31	0.43	0.53	0.74	0.94	1.2	1.6	2.3															
R	2000			0.20	0.27	0.33	0.46	0.59	0.77	1.0	1.4																

LQ (DEFECTS)
10%

LQ (DEFECTIVES)
5.0%

TABLE VII-A—Limiting Quality (in percent defective) for which P_a = 5 Percent
(for Normal Inspection, Single sampling)

(See 11.6)

Code letter	Sample size	Acceptable Quality Level															
		0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10
A	2															78	
B	3														63		
C	5													45			66
D	8												31			47	60
E	13											21			32	41	50
F	20										14			22	28	34	46
G	32									8.9			14	18	23	30	37
H	50								5.8			9.1	12	15	20	25	32
J	80							3.7			5.8	7.7	9.4	13	16	20	26
K	125						2.4			3.8	5.0	6.2	8.4	11	14	18	24
L	200					1.5			2.4	3.2	3.9	5.3	6.6	8.5	11	15	
M	315				0.95			1.5	2.0	2.5	3.3	4.2	5.4	7.0	9.6		
N	500			0.60			0.95	1.3	1.6	2.1	2.6	3.4	4.4	6.1			
P	800		0.38			0.59	0.79	0.97	1.3	1.6	2.1	2.7	3.8				
Q	1250	0.24			0.38	0.50	0.62	0.84	1.1	1.4	1.8	2.4					
R	2000			0.24	0.32	0.39	0.53	0.66	0.85	1.1	1.5						

TABLE VII-B—Limiting Quality (in defects per hundred units) for which P_a = 5 Percent
(for Normal Inspection, Single sampling)

(See 11.6)

Code letter	Sample size	Acceptable Quality Level																									
		0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
A	2															150			240	320	390	530	660	850	1100	1500	2000
B	3														100			160	210	260	350	440	570	730	1000	1400	1900
C	5													60			95	130	160	210	260	340	440	610	810	1100	
D	8												38			59	79	97	130	160	210	270	380	510	710		
E	13											23			37	48	60	81	100	130	170	230	310	440			
F	20										15			24	32	39	53	66	85	110	150						
G	32									9.4			15	20	24	33	41	53	68	95							
H	50								6.0			9.5	13	16	21	26	34	44	61								
J	80							3.8			5.9	7.9	9.7	13	16	21	27	38									
K	125						2.4			3.8	5.0	6.2	8.4	11	14	18	24										
L	200					1.5			2.4	3.2	3.9	5.3	6.6	8.5	11	15											
M	315				0.95			1.5	2.0	2.5	3.3	4.2	5.4	7.0	9.6												
N	500			0.60			0.95	1.3	1.6	2.1	2.6	3.4	4.4	6.1													
P	800		0.38			0.59	0.79	0.97	1.3	1.6	2.1	2.7	3.8														
Q	1250	0.24			0.38	0.50	0.62	0.84	1.1	1.4	1.8	2.4															
R	2000			0.24	0.32	0.39	0.53	0.66	0.85	1.1	1.5																

LQ (DEFECTS)
5%

TABLE VIII — Limit Numbers for Reduced Inspection

(See 8.3.3)

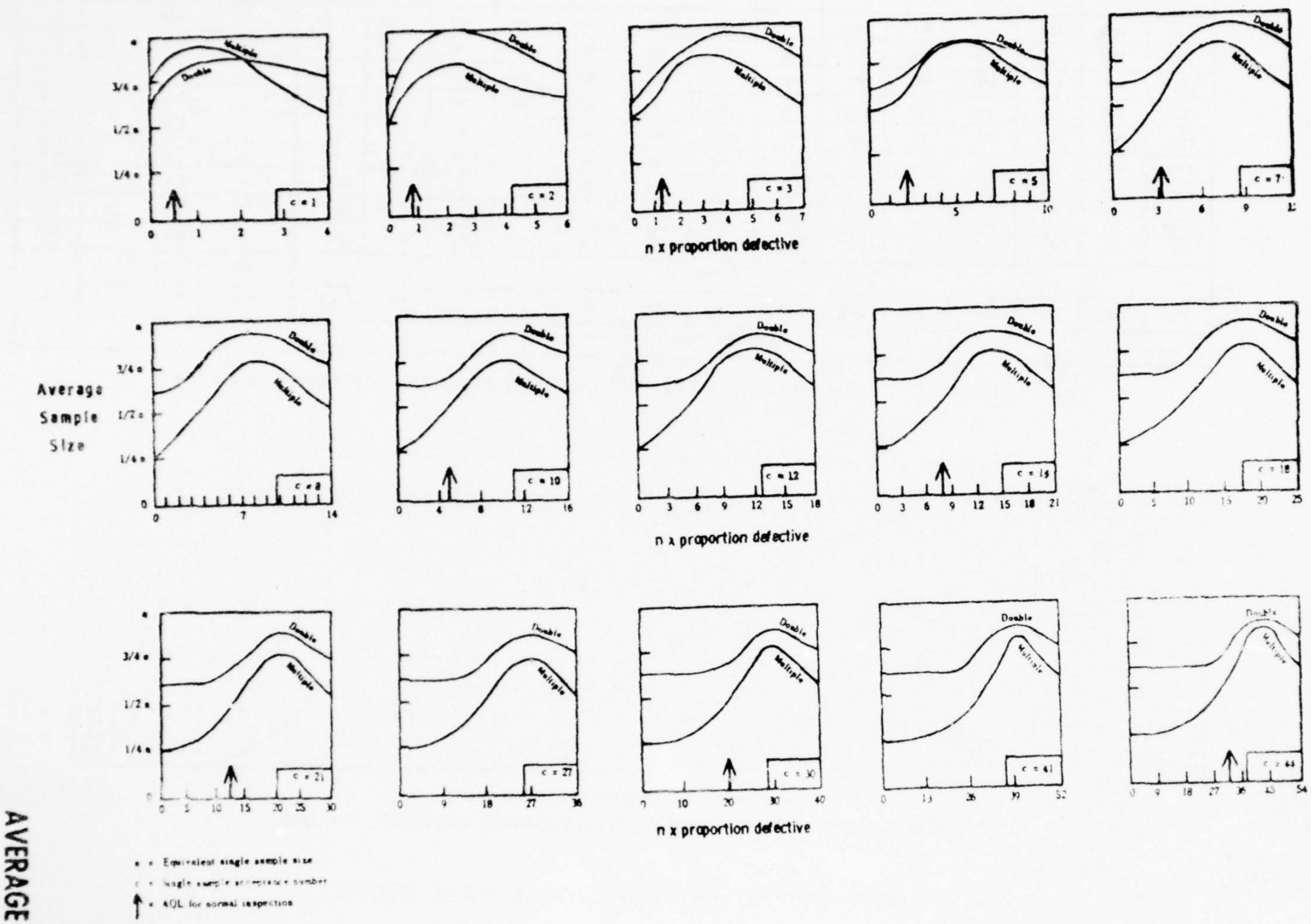
Number of sample units from last 10 lots or batches	Acceptable Quality Level																									
	0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
20 - 29	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	2	4	8	14	22	40	68	115	181
30 - 49	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	1	3	7	13	22	36	63	105	178	277
50 - 79	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	2	3	7	14	25	40	63	110	181	301	
80 - 129	*	*	*	*	*	*	*	*	*	*	*	*	0	0	2	4	7	14	24	42	68	105	181	297		
130 - 199	*	*	*	*	*	*	*	*	*	*	*	0	0	2	4	7	13	25	42	72	115	177	301	490		
200 - 319	*	*	*	*	*	*	*	*	*	*	0	0	2	4	8	14	22	40	68	115	181	277	471			
320 - 499	*	*	*	*	*	*	*	*	*	0	0	1	4	8	14	24	39	68	113	189						
500 - 799	*	*	*	*	*	*	*	*	0	0	2	3	7	14	25	40	63	110	181							
800 - 1249	*	*	*	*	*	*	*	0	0	2	4	7	14	24	42	68	105	181								
1250 - 1999	*	*	*	*	*	*	0	0	2	4	7	13	24	40	69	110	169									
2000 - 3149	*	*	*	*	*	0	0	2	4	8	14	22	40	68	115	181										
3150 - 4999	*	*	*	*	0	0	1	4	8	14	24	38	67	111	186											
5000 - 7999	*	*	*	0	0	2	3	7	14	25	40	63	110	181												
8000 - 12499	*	*	0	0	2	4	7	14	24	42	68	105	181													
12500 - 19999	*	0	0	2	4	7	13	24	40	69	110	169														
20000 - 31499	0	0	2	4	8	14	22	40	68	115	181															
31500 - 49999	0	1	4	8	14	24	38	67	111	186																
50000 & Over	2	3	7	14	25	40	63	110	181	301																

* Denotes that the number of sample units from the last ten lots or batches is not sufficient for reduced inspection for this AQL. In this instance more than ten lots or batches may be used for the calculation, provided that the lots or batches used are the most recent ones in sequence, that they have all been on normal inspection, and that none has been rejected while on original inspection.

LIMIT
NUMBERS

TABLE IX — *Average sample size curves for double and multiple sampling (normal and tightened inspection)*

(See 11.5)

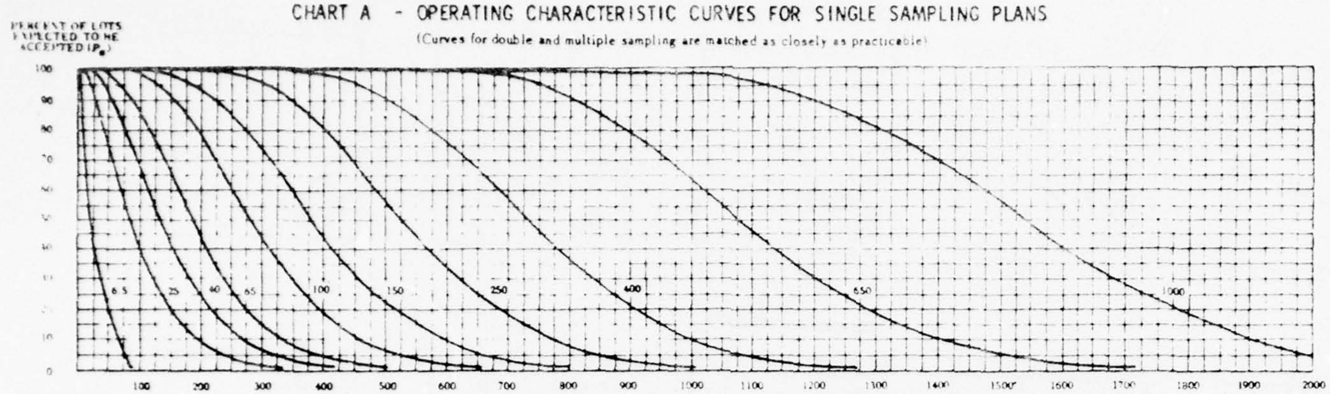


A

TABLE X-A—Tables for sample size code letter: A

CHART A - OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

(Curves for double and multiple sampling are matched as closely as practicable)



QUALITY OF SUBMITTED LOTS (p, in percent defective for AQL's $\leq$ 10; in defects per hundred units for AQL's $>$ 10)

Note: Figures on curves are Acceptable Quality Levels (AQL's) for normal inspection.

TABLE X-A-1 - TABULATED VALUES FOR OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

P_a	Acceptable Quality Levels (normal inspection)														
	6.5	6.5	25	40	65	100	150	X	250	X	400	X	650	X	1000
	p (in percent defective)	p (in defects per hundred units)													
99.0	0.501	0.51	7.45	21.8	41.2	89.2	145	175	239	305	374	517	629	859	977
95.0	2.53	2.56	17.8	40.9	68.3	131	199	235	308	385	462	622	745	995	1122
90.0	5.13	5.25	26.6	55.1	87.3	158	233	272	351	432	515	684	812	1073	1206
75.0	13.4	14.4	48.1	86.8	127	211	298	342	431	521	612	795	934	1314	1354
50.0	29.3	34.7	83.9	134	184	284	383	433	533	633	733	933	1083	1383	1533
25.0	50.0	69.3	135	196	256	371	484	540	651	761	870	1087	1248	1568	1728
10.0	68.4	115	195	266	334	464	589	650	770	889	1006	1238	1409	1748	1916
5.0	77.6	150	237	315	388	526	657	722	848	972	1094	1334	1512	1862	2035
1.0	90.0	230	332	420	502	655	800	870	1007	1141	1272	1529	1718	2088	2270
	X	X	40	65	100	150	X	250	X	400	X	650	X	1000	X
	Acceptable Quality Levels (tightened inspection)														

Note: Binomial distribution used for percent defective computations; Poisson for defects per hundred units.

TABLE X-A-2 - SAMPLING PLANS FOR SAMPLE SIZE CODE LETTER: A

Type of sampling plan	Cumulative sample size	Acceptable Quality Levels (normal inspection)																		Cumulative sample size
		Less than 6.5	6.5	×	10	15	25	40	65	100	150	×	250	×	400	×	650	×	1000	
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	
Single	2	▽	0 1	Use Letter D	Use Letter C	Use Letter B	1 2	2 3	3 4	5 6	7 8	8 9	10 11	12 13	14 15	18 19	21 22	27 28	30 31	2
Double		▽	•				(•)	(•)	(•)	(•)	(•)	(•)	(•)	(•)	(•)	(•)	(•)	(•)	(•)	
Multiple		▽	•				•	•	•	•	•	•	•	•	•	•	•	•	•	
		Less than 10	×	10	15	25	40	65	100	150	×	250	×	400	×	650	×	1000	×	
		Acceptable Quality Levels (tightened inspection)																		

▽ = Use next subsequent sample size code letter for which acceptance and rejection numbers are available

Ac = Acceptance number

Re = Rejection number

• = Use single sampling plan above (or alternatively use letter D)

(•) = Use single sampling (or alternatively use letter B)

A

AD-A037 253 AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OHIO SCHO--ETC F/G 15/5
QUALITY CONTROL IN DOD,(U)
JAN 77 G A BOHLEN, P J SWEENEY
UNCLASSIFIED AU-AFIT-SL-22 NL

3 OF 4
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A037253

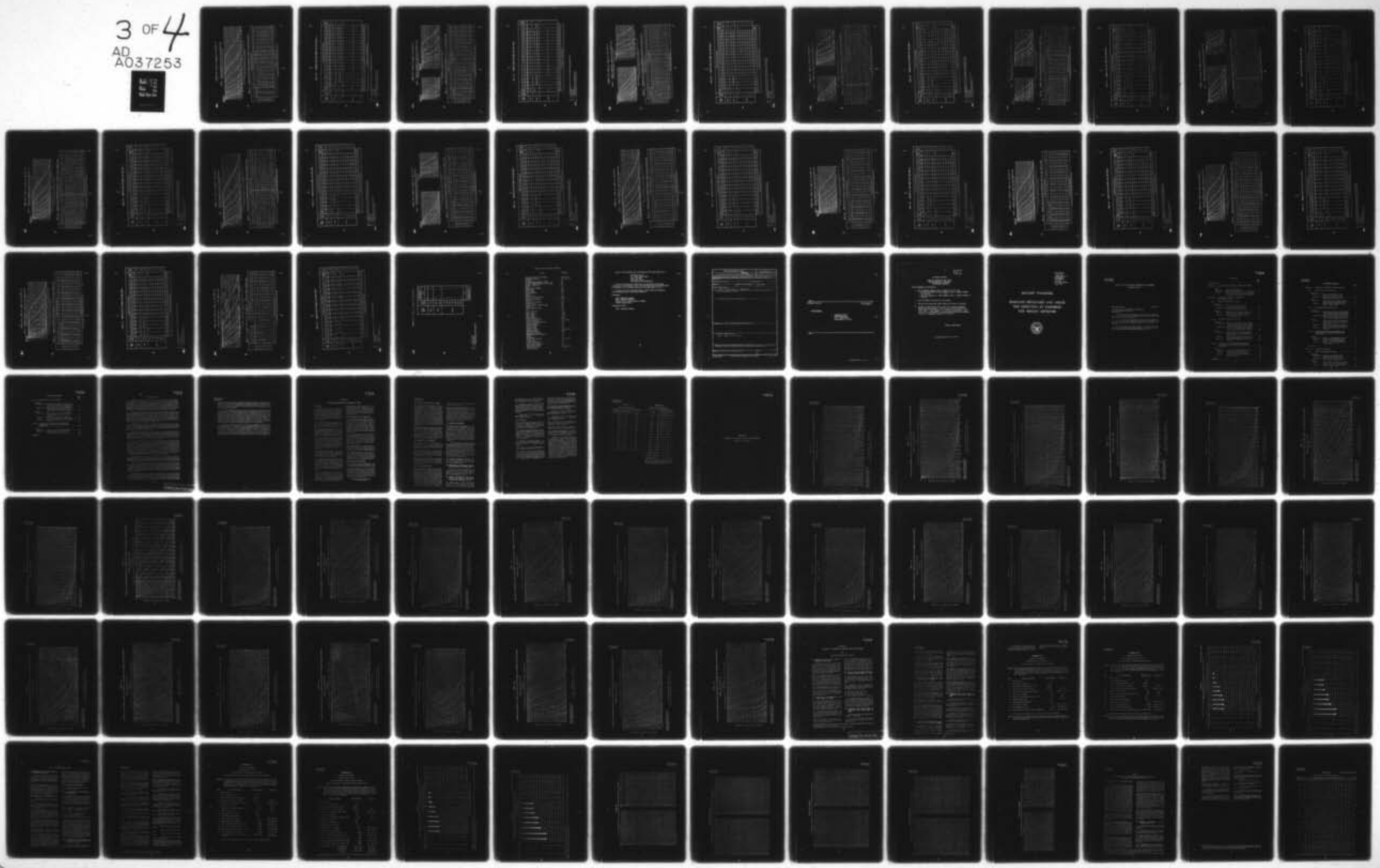
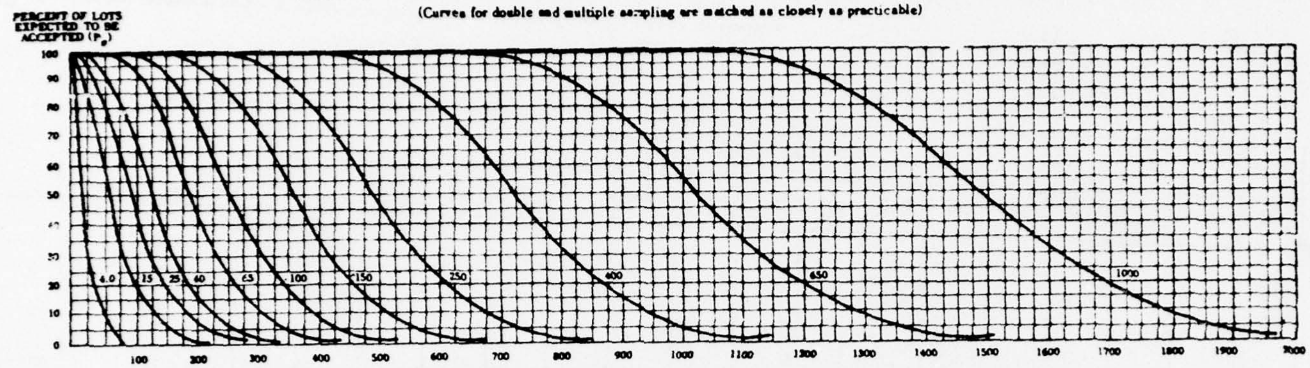


TABLE X-B—Tables for sample size code letter: B

B

CHART B - OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

(Curves for double and multiple sampling are matched as closely as practicable)



QUALITY OF SUBMITTED LOTS (p, in percent defective for AQL's ≤ 10; in defects per hundred units for AQL's > 10)

Note: Figures on curves are Acceptable Quality Levels (AQL's) for normal inspection.

32

TABLE X-B-1 - TABULATED VALUES FOR OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

P_a	Acceptable Quality Levels (normal inspection)																
	4.0	4.0	15	25	40	65	100	X	150	X	250	X	400	X	660	X	1000
	p (in percent defective)	p (in defects per hundred units)															
99.0	0.33	0.34	4.97	14.5	27.4	59.5	96.9	117	159	203	249	345	419	573	651	947	1029
95.0	1.70	1.71	11.8	27.3	45.5	87.1	133	157	206	256	308	415	496	663	748	1065	1153
90.0	3.45	3.50	17.7	36.7	58.2	105	155	181	234	288	343	456	541	716	804	1131	1222
75.0	9.14	9.60	32.0	57.6	84.5	141	199	228	287	347	408	530	623	809	903	1249	1344
50.0	20.6	23.1	55.9	89.1	122	189	256	289	356	422	489	622	722	922	1022	1389	1489
25.0	37.0	46.2	89.8	131	170	247	323	360	434	507	580	724	832	1046	1152	1539	1644
10.0	53.6	76.8	130	177	223	309	392	433	514	593	671	825	939	1165	1277	1683	1793
5.0	63.2	99.9	158	210	258	350	438	481	565	648	730	890	1008	1241	1356	1773	1886
1.0	78.4	154	221	280	335	437	533	580	672	761	848	1019	1145	1392	1513	1951	2069
	6.5	6.5	25	40	65	100	X	150	X	250	X	400	X	650	X	1000	X
	Acceptable Quality Levels (tightened inspection)																

Note: Binomial distribution used for percent defective computations; Poisson for defects per hundred units.

TABLE X-B-2 - SAMPLING PLANS FOR SAMPLE SIZE CODE LETTER: B

Type of sampling plan	Cumulative sample size	Acceptable Quality Levels (normal inspection)																				Cumulative sample size
		Less than 4.0	4.0	6.5	X	10	15	25	40	65	100	X	150	X	250	X	400	X	650	X	1000	
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	
Single	3	▽	0 1	Use Letter A	Use Letter D	Use Letter C	1 2	2 3	3 4	5 6	7 8	8 9	10 11	12 13	14 15	18 19	21 22	27 28	30 31	41 42	44 45	3
Double	2	▽	•				0 2	0 3	1 4	2 5	3 7	3 7	5 9	6 10	7 11	9 14	11 16	15 20	17 22	23 29	25 31	2
	4						1 2	3 4	4 5	6 7	8 9	11 12	12 13	15 16	18 19	23 24	26 27	34 35	37 38	52 53	56 57	4
Multiple		▽	•				‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	
		Less than 6.5	6.5	X	10	15	25	40	65	100	X	150	X	250	X	400	X	650	X	1000	X	
		Acceptable Quality Levels (tightened inspection)																				

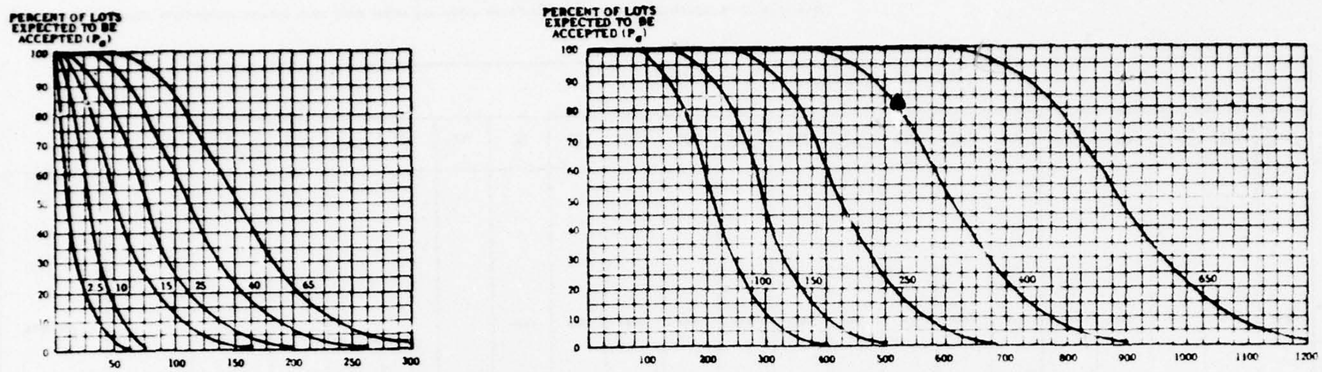
▽ = Use next subsequent sample size code letter for which acceptance and rejection numbers are available.
Ac = Acceptance number
Re = Rejection number
• = Use single sampling plan above (or alternatively use letter E).
‡ = Use double sampling plan above (or alternatively use letter D).

B

TABLE X-C—Tables for sample size code letter: C

CHART C - OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

(Curves for double and multiple sampling are matched as closely as practicable)



QUALITY OF SUBMITTED LOTS (p, in percent defective for AQL's ≤ 10, in defects per hundred units for AQL's > 10)

Note: Figures on curves are Acceptable Quality Levels (AQL's) for normal inspection

TABLE X-C-1 - TABULATED VALUES FOR OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

P_a	Acceptable Quality Levels (normal inspection)																		
	2.5	10	2.5	10	15	25	40	65	X	100	X	150	X	250	X	400	X	650
	p (in percent defective)		p (in defects per hundred units)															
99.0	0.20	3.28	0.20	2.89	8.72	16.5	35.7	58.1	70.1	95.4	122	150	207	251	344	391	568	618
95.0	1.02	7.63	1.03	7.10	16.4	27.3	52.3	79.6	93.9	123	154	185	249	298	398	449	639	691
90.0	2.09	11.2	2.10	10.6	22.0	34.9	63.0	93.1	109	140	173	206	273	325	429	482	679	733
75.0	5.59	19.4	5.76	19.2	34.5	50.7	84.4	119	137	172	208	245	318	374	485	542	749	806
50.0	12.9	31.4	13.9	33.6	53.5	73.4	113	153	173	213	253	293	373	433	553	613	833	893
25.0	24.2	45.4	27.7	53.9	78.4	102	148	194	216	260	304	348	435	499	627	691	923	987
10.0	36.9	58.4	46.1	77.8	106	134	186	235	260	308	356	403	495	564	699	766	1010	1076
5.0	45.1	65.8	59.9	94.9	126	155	210	263	289	339	389	438	534	605	745	814	1064	1131
1.0	60.2	77.8	92.1	133	168	201	262	326	348	403	456	509	612	687	835	908	1171	1241
	4.0	X	4.0	15	25	40	65	X	100	X	150	X	250	X	400	X	650	X
	Acceptable Quality Levels (tightened inspection)																		

Note: Binomial distribution used for percent defective computations, Poisson for defects per hundred units

TABLE X-C-2 - SAMPLING PLANS FOR SAMPLE SIZE CODE LETTER: C

Type of sampling plan	Cumulative sample size	Less than 2.5	2.5	4.0	X	6.5	10	15	25	40	65	X	100	X	150	X	250	X	400	X	650	1000	Cumulative sample size
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	
Single	5	▽	0 1	Use Letter B	Use Letter E	Use Letter D	1 2	2 3	3 4	5 6	7 8	8 9	10 11	12 13	14 15	18 19	21 22	27 28	30 31	41 42	44 45	Use Letter B	5
Double	3	▽	•				0 2	0 3	1 4	2 5	3 7	3 7	5 9	6 10	7 11	9 14	11 16	15 20	17 22	23 29	25 31		3
	6						1 2	3 4	4 5	6 7	8 9	11 12	12 13	15 16	18 19	23 24	26 27	34 35	37 38	52 53	56 57		6
Multiple		▽	•				++	++	++	++	++	++	++	++	++	++	++	++	++	++	++		
		Less than 4.0	4.0	X	6.5	10	15	25	40	65	X	100	X	150	X	250	X	400	X	650	X	1000	

Acceptable Quality Levels (tightened inspection)

▽ = Use next subsequent sample size code letter for which acceptance and rejection numbers are available.

Ac = Acceptance number.

Re = Rejection number.

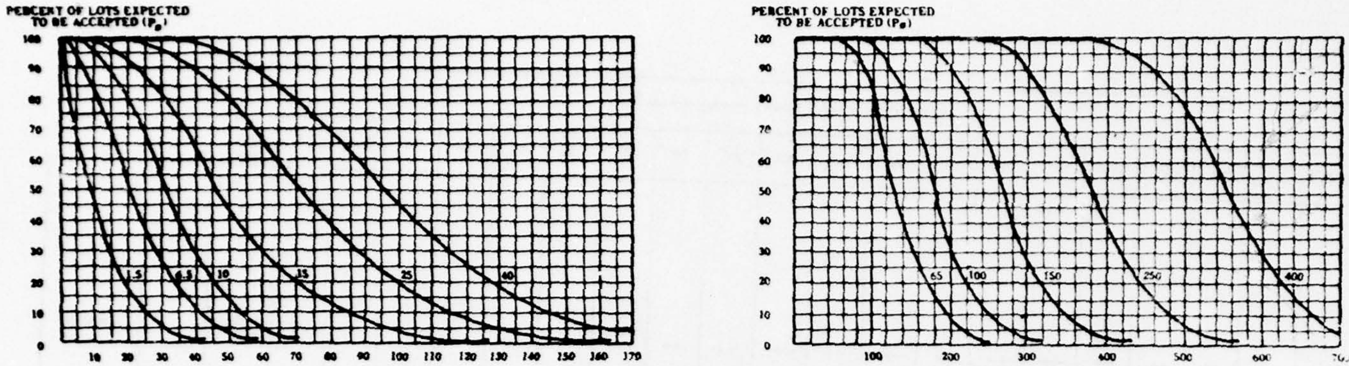
• = Use single sampling plan above (or alternatively use letter F).

++ = Use double sampling plan above (or alternatively use letter D).

TABLE X-D—Tables for sample size code letter: D

CHART D - OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

(Curves for double and multiple sampling are matched as closely as practicable)



QUALITY OF SUBMITTED LOTS (p, in percent defective for AQL's $\leq$ 10; in defects per hundred units for AQL's $>$ 10)

Note: Figures on curves are Acceptable Quality Levels (AQL's) for normal inspection.

TABLE X-D-1 - TABULATED VALUES FOR OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

P_a	Acceptable Quality Levels (normal inspection)																		
	1.5	6.5	10	1.5	6.5	10	15	25	40	X	65	X	100	X	150	X	250	X	400
	p (in percent defective)			p (in defects per hundred units)															
99.0	0.13	2.00	6.00	0.13	1.86	5.45	10.3	22.3	36.3	43.8	59.6	76.2	93.5	129	157	215	244	355	386
95.0	0.64	2.64	11.1	0.64	4.44	10.2	17.1	32.7	49.8	58.7	77.1	96.1	116	156	186	249	281	399	432
90.0	1.31	6.88	14.7	1.31	6.65	13.8	21.8	39.4	58.2	67.9	87.8	108	129	171	203	268	301	424	458
75.0	3.53	12.1	22.1	3.60	12.0	21.6	31.7	52.7	74.5	85.5	108	130	153	199	234	303	339	468	504
50.0	8.30	20.1	32.1	8.66	21.0	33.4	45.9	70.9	95.9	108	133	158	183	233	271	346	383	521	558
25.0	15.9	30.3	43.3	17.3	33.7	49.0	63.9	92.8	121	135	163	190	218	272	312	392	432	577	617
10.0	25.0	40.6	53.9	28.8	48.6	66.5	83.5	116	147	162	193	222	252	309	352	437	478	631	672
5.0	31.2	47.1	59.9	37.5	59.3	78.7	96.9	131	164	180	212	243	274	334	378	465	509	665	707
1.0	43.8	58.8	70.7	57.6	83.0	105	126	164	200	218	252	285	318	382	429	522	568	732	776
	2.5	10	X	2.5	10	15	25	40	X	65	X	100	X	150	X	250	X	400	X
	Acceptable Quality Levels (tightened inspection)																		

D

TABLE X-D-2 - SAMPLING PLANS FOR SAMPLE SIZE CODE LETTER: D

Type of sampling plan	Cumulative sample size	Acceptable Quality Levels (normal inspection)																					Cumulative sample size
		Less than 1.5	1.5	2.5	X	4.0	6.5	10	15	25	40	X	65	X	100	X	150	X	250	X	400	Higher than 400	
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	
Single	8	▽	0 1				1 2	2 3	3 4	5 6	7 8	8 9	10 11	12 13	14 15	18 19	21 22	27 28	30 31	41 42	44 45	△	8
Double	5	▽	•	Use Letter C	Use Letter F	Use Letter E	0 2	0 3	1 4	2 5	3 7	3 7	5 9	6 10	7 11	9 14	11 16	15 20	17 22	23 29	25 31	△	5
	10						1 2	3 4	4 5	6 7	8 9	11 12	12 13	15 16	18 19	23 24	26 27	34 35	37 38	52 53	56 57		10
Multiple	2	▽	•				# 2	# 2	# 3	# 4	0 4	0 4	0 5	0 6	1 7	1 8	2 9	3 10	4 12	6 15	6 16	△	2
	4						# 2	0 3	0 3	1 5	1 6	2 7	3 8	3 9	4 10	6 12	7 14	10 17	11 19	16 25	17 27		4
	6						0 2	0 3	1 4	2 6	3 8	4 9	6 10	7 12	8 13	11 17	13 19	17 24	19 27	26 36	29 39		6
	8						0 3	1 4	2 5	3 7	5 10	6 11	8 13	10 15	12 17	16 22	19 25	24 31	27 34	37 46	40 49		8
	10						1 3	2 4	3 6	5 8	7 11	9 12	11 15	14 17	17 20	22 25	25 29	32 37	36 40	49 55	53 58		10
	12						1 3	3 5	4 6	7 9	10 12	12 14	14 17	18 20	21 23	27 29	31 33	40 43	45 47	61 64	65 68		12
	14						2 3	4 5	6 7	9 10	13 14	14 15	18 19	21 22	25 26	32 33	37 38	48 49	53 54	72 73	77 78		14
		Less than 2.5	2.5	X	4.0	6.5	10	15	25	40	X	65	X	100	X	150	X	250	X	400	X	Higher than 400	
		Acceptable Quality Levels (tightened inspection)																					

△ = Use next preceding sample size code letter for which acceptance and rejection numbers are available.

▽ = Use next subsequent sample size code letter for which acceptance and rejection numbers are available.

Ac = Acceptance number

Re = Rejection number

• = Use single sampling plan above (or alternatively use letter G).

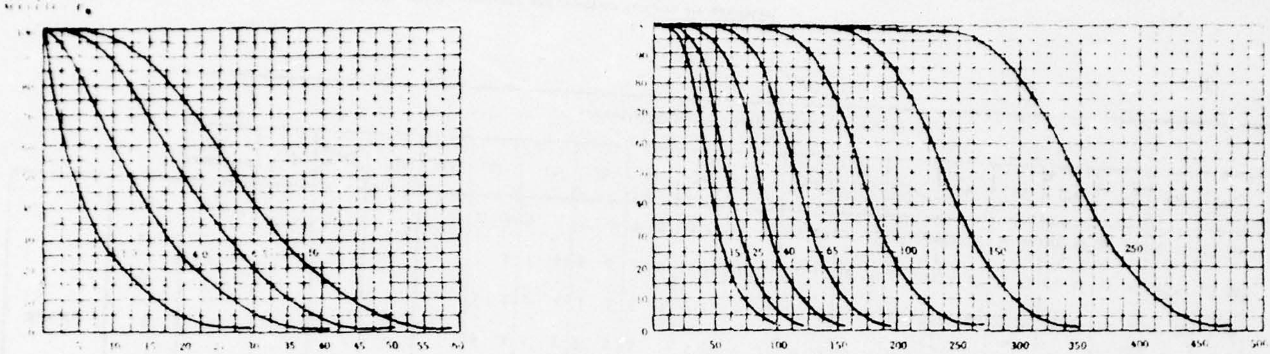
= Acceptance not permitted at this sample size

D

TABLE X-E—Tables for sample size code letter: E

CHART E - OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

(Curves for double and multiple sampling are matched as closely as practicable)



QUALITY OF SUBMITTED LOTS (p, in percent defective for AQL's ≤ 10; in defects per hundred units for AQL's > 10)

Note: Figures on curves are Acceptable Quality Levels (AQL's) for normal inspection.

TABLE X-E-1 - TABULATED VALUES FOR OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

P_a	Acceptable Quality Levels (normal inspection)																			
	1.0	4.0	6.5	10	1.0	4.0	6.5	10	15	25	X	40	X	65	X	100	X	150	X	250
	p (in percent defective)				p (in defects per hundred units)															
99.0	0.077	1.19	3.63	7.00	0.078	1.15	3.35	6.33	13.7	22.4	27.0	36.7	46.9	57.5	79.6	96.7	132	150	219	238
95.0	0.394	2.81	6.63	11.3	0.395	2.73	6.29	10.5	20.1	30.6	36.1	47.5	59.2	71.2	95.7	115	153	173	246	266
90.0	0.807	4.16	8.80	14.2	0.806	4.09	8.48	13.4	24.2	35.8	41.8	54.0	66.5	79.2	105	125	165	185	261	282
75.0	2.19	7.41	13.4	19.9	2.22	7.39	13.5	19.5	32.5	45.8	52.6	66.3	80.2	94.1	122	144	187	208	268	315
50.0	5.19	12.6	20.0	27.5	5.33	12.9	20.6	28.2	33.6	59.0	66.7	82.1	97.5	113	144	168	213	236	321	344
25.0	10.1	19.4	28.0	36.2	10.7	20.7	30.2	39.3	57.1	74.5	83.1	100	117	134	167	192	241	266	355	379
10.0	16.2	26.8	[illegible]	[illegible]	[illegible]	[illegible]	40.9	51.4	[illegible]	90.5	100	119	137	155	190	217	269	295	388	414
5.0	20.6	31.6	41.0	49.5	23.0	36.5	48.4	59.6	80.9	101	111	130	150	168	205	233	286	313	409	435
1.0	29.8	41.5	50.6	58.7	35.4	51.1	64.7	77.3	101	123	134	155	176	196	235	264	321	349	450	477
	1.5	6.5	10	X	1.5	6.5	10	15	25	X	40	X	65	X	100	X	150	X	250	X
	Acceptable Quality Levels (tightened inspection)																			

Note: Binomial distribution used for percent defective computations; Poisson for defects per hundred units.

E

TABLE X-E-2 - SAMPLING PLANS FOR SAMPLE SIZE CODE LETTER: E

Type of sampling plan	Cumulative sample size	Acceptable Quality Levels (normal inspection): Less than 1.0	1.0	1.5	X	2.5	4.0	6.5	10	15	25	X	40	X	65	X	100	X	150	X	250	Higher than 250	Cumulative sample size
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	
Single	13	▽	0 1	Use Letter D	Use Letter G	Use Letter F	1 2	2 3	3 4	5 6	7 8	8 9	10 11	12 13	14 15	18 19	21 22	27 28	30 31	41 42	44 45	△	13
Double	8	▽	•				0 2	0 3	1 4	2 5	3 7	3 7	5 9	6 10	7 11	9 14	11 16	15 20	17 22	23 29	25 31	△	8
	16						1 2	3 4	4 5	6 7	8 9	11 12	12 13	15 16	18 19	23 24	26 27	34 35	37 38	52 53	56 57		16
Multiple	3	▽	•				# 2	# 2	# 3	# 4	0 4	0 4	0 5	0 6	1 7	1 8	2 9	3 10	4 12	6 15	6 16	△	3
	6						# 2	0 3	0 3	1 5	1 6	2 7	3 8	3 9	4 10	6 12	7 14	10 17	11 19	16 25	17 27		6
	9						0 2	0 3	1 4	2 6	3 8	4 9	6 10	7 12	8 13	11 17	13 19	17 24	19 27	26 36	29 39		9
	12						0 3	1 4	2 5	3 7	5 10	6 11	8 13	10 15	12 17	16 22	19 25	24 31	27 34	37 46	40 49		12
	15						1 3	2 4	3 6	5 8	7 11	9 12	11 15	14 17	17 20	22 25	25 29	32 37	36 40	49 55	53 58		15
	18						1 3	3 5	4 [illegible]	[illegible]	[illegible] 12	12 14	14 17	18 20	21 23	27 29	31 33	40 43	45 47	61 64	65 68		18
	21						2 3	4 5	6 7	9 10	13 14	14 15	18 19	21 22	25 26	32 33	37 38	48 49	53 54	72 73	77 78		21
		Less than 1.5	1.5	X	2.5	4.0	6.5	10	15	25	X	40	X	65	X	100	X	150	X	250	X	Higher than 250	
		Acceptable Quality Levels (tightened inspection)																					

△ = Use next preceding sample size code letter for which acceptance and rejection numbers are available.

▽ = Use next subsequent sample size code letter for which acceptance and rejection numbers are available.

Ac = Acceptance number.

Re = Rejection number.

• = Use single sampling plan above (or alternatively use letter H).

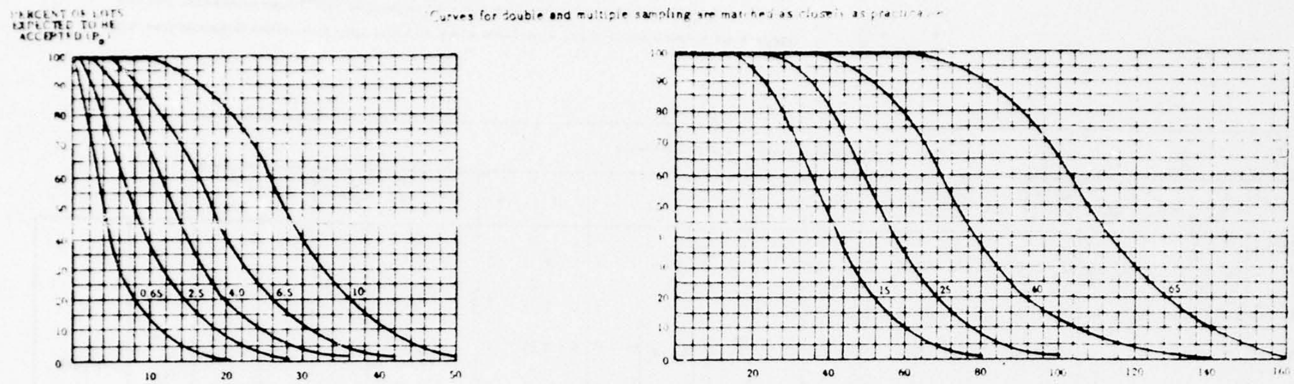
= Acceptance not permitted at this sample size.

E

TABLE X-F — Tables for sample size code letter: F

CHART F - OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

(Curves for double and multiple sampling are matched as closely as practicable)



QUALITY OF SUBMITTED LOTS (p, in percent defective for AQL's ≤ 10; in defects per hundred units for AQL's > 10)

Note: Figures on curves are Acceptable Quality Levels (AQL's) for normal inspection

TABLE X-F-1 - TABULATED VALUES FOR OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

P_a	Acceptable Quality Levels (normal inspection)																
	0.65	2.5	4.0	6.5	10	0.65	2.5	4.0	6.5	10	15	X	25	X	40	X	65
	p (in percent defective)					p (in defects per hundred units)											
99.0	0.050	0.75	2.25	4.31	9.75	0.051	0.75	2.18	4.12	8.92	14.5	17.5	23.9	30.5	37.4	51.7	[illegible]
95.0	0.256	1.80	4.22	7.13	14.0	0.257	1.78	4.09	6.83	13.1	19.9	23.5	30.8	38.5	46.2	62.2	74.5
90.0	0.525	2.69	5.64	9.03	16.6	0.527	2.66	5.51	8.73	15.8	23.3	27.2	35.1	43.2	51.5	68.4	81.2
75.0	1.43	4.81	8.70	12.8	21.6	1.44	4.81	8.68	12.7	21.1	29.8	34.2	43.1	52.1	61.2	79.5	93.4
50.0	3.41	8.25	13.1	18.1	27.9	3.47	8.39	13.4	18.4	28.4	38.3	43.3	53.3	63.3	73.3	93.3	108
25.0	6.70	12.9	18.7	24.2	34.8	6.93	13.5	19.6	25.5	37.1	48.4	54.0	65.1	76.1	87.0	109	125
10.0	10.9	18.1	24.5	30.4	41.5	11.5	19.5	26.6	33.4	46.4	58.9	65.0	77.0	88.9	101	124	147
5.0	13.9	21.6	28.3	34.4	45.6	15.0	23.7	31.5	38.8	52.6	65.7	72.2	84.8	97.2	109	133	151
1.0	20.6	28.9	35.6	42.0	53.4	23.0	33.2	42.0	50.2	65.5	80.0	87.0	101	114	127	153	172
	1.0	4.0	6.5	10	X	1.0	4.0	6.5	10	15	X	25	X	40	X	65	X
	Acceptable Quality Levels (tightened inspection)																

Note: Binomial distribution used for percent defective computations; Poisson for defects per hundred units

TABLE X-F-2 - SAMPLING PLANS FOR SAMPLE SIZE CODE LETTER: F

Type of sampling plan	Cumulative sample size	Acceptable Quality Levels (normal inspection)																																		Cumulative sample size
		Less than 0.65		0.65		1.0		X		1.5		2.5		4.0		6.5		10		15		X		25		X		40		X		65		Higher than 65		
		Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	
Single	20	▽		0	1	Use Letter E		Use Letter H		Use Letter G		1	2	2	3	3	4	5	6	7	8	8	9	10	11	12	13	14	15	18	19	21	22	△		20
Double	13	▽		*								0	2	0	3	1	4	2	5	3	7	3	7	5	9	6	10	7	11	9	14	11	16	△		13
	26											1	2	3	4	4	5	6	7	8	9	11	12	12	13	15	16	18	19	23	24	26	27			26
Multiple	5	▽		*								#	2	#	2	#	3	#	4	0	4	0	4	0	5	0	6	1	7	1	8	2	9	△		5
	10											#	2	0	3	0	3	1	5	1	6	2	7	3	8	3	9	4	10	6	12	7	14			10
	15											0	2	0	3	1	4	2	6	3	8	4	9	6	10	7	12	8	13	11	17	13	19			15
	20											0	3	1	4	2	5	3	7	5	10	6	11	8	13	10	15	12	17	16	22	19	25			20
	25											1	3	2	4	3	6	5	8	7	11	9	12	11	15	14	17	17	20	22	25	25	29			25
	30											1	3	3	5	4	6	7	9	10	12	12	14	14	17	18	20	21	23	27	29	31	33			30
	35											2	3	4	5	6	7	9	10	13	14	14	15	18	19	21	22	25	26	32	33	37	38			35
		Less than 1.0		1.0		X		1.5		2.5		4.0		6.5		10		15		X		25		X		40		X		65		X		Higher than 65		
		Acceptable Quality Levels (tightened inspection)																																		

△ = Use next preceding sample size code letter for which acceptance and rejection numbers are available

▽ = Use next subsequent sample size code letter for which acceptance and rejection numbers are available

Ac = Acceptance number

Re = Rejection number

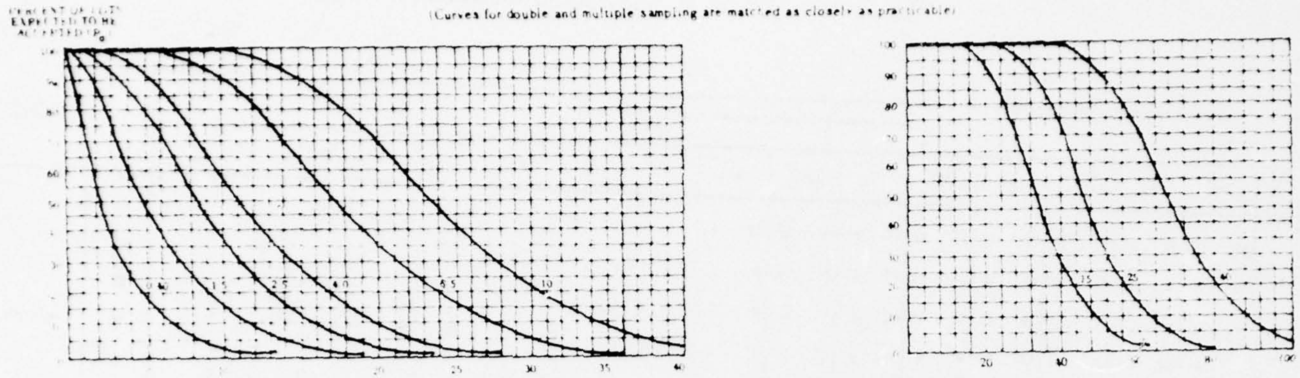
* = Use single sampling plan above (or alternatively use letter I)

= Acceptance not permitted at this sample size

TABLE X-G—Tables for sample size code letter: G

CHART G - OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

(Curves for double and multiple sampling are matched as closely as practicable)



QUALITY OF SUBMITTED LOTS (p, in percent defective for AQL's ≤ 10; in defects per hundred units for AQL's > 10)

Note: Figures on curves are Acceptable Quality Levels (AQL's) for normal inspection.

TABLE X-G-1 - TABULATED VALUES FOR OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

P_a	Acceptable Quality Levels (normal inspection)																	
	0.40	1.5	2.5	4.0	6.5	10	0.40	1.5	2.5	4.0	6.5	10	X	15	X	25	X	40
	p (in percent defective)						p (in defects per hundred units)											
99.0	0.032	0.475	1.38	2.63	5.94	9.75	0.032	0.466	1.36	2.57	5.57	8.68	11.9	14.9	19.1	23.4	32.5	[illegible]
95.0	0.161	1.16	2.59	4.39	8.50	13.1	0.160	1.10	2.55	4.26	[illegible]	12.4	14.7	19.1	24.6	28.5	38.9	46.5
90.0	[illegible]	1.67	3.50	5.56	10.2	15.1	0.328	1.66	3.44	5.45	9.50	14.6	17.0	21.9	27.0	32.2	42.7	50.8
75.0	[illegible]	3.01	5.42	7.98	13.4	19.0	0.900	3.60	5.39	7.92	13.2	18.6	21.4	26.9	32.6	38.2	49.7	59.4
50.0	2.14	5.19	8.27	11.4	17.5	23.7	2.16	5.24	8.35	11.5	17.7	24.0	27.1	33.3	39.6	45.8	58.3	67.7
25.0	4.23	[illegible]	[illegible]	15.4	22.3	29.0	4.33	8.4	12.1	15.9	23.1	[illegible]	35.8	40.7	[illegible]	54.4	[illegible]	78.0
10.0	6.94	[illegible]	15.8	19.7	27.1	34.1	7.19	12.2	16.6	20.9	29.6	36.8	40.6	48.1	[illegible]	62.9	77.4	[illegible]
5.0	8.94	13.6	18.4	22.5	30.1	37.2	9.36	14.8	19.7	24.2	32.9	41.1	45.1	53.0	58.5	66.3	80.4	94.5
1.0	[illegible]	[illegible]	23.7	28.0	35.9	43.5	14.4	20.7	[illegible]	[illegible]	[illegible]	50.0	54.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0.65	2.5	4.0	6.5	10	X	0.65	2.5	4.0	6.5	10	X	15	X	25	X	40	X
	Acceptable Quality Levels (tightened inspection)																	

Note: Binomial distribution used for percent defective computations; Poisson for defects per hundred units.

G

TABLE X-G-2 - SAMPLING PLANS FOR SAMPLE SIZE CODE LETTER: G

Type of sampling plan	Cumulative sample size	Acceptable Quality Levels (normal inspection)																																		Cumulative sample size
		Less than 0.40		0.40		0.65		X		1.0		1.5		2.5		4.0		6.5		10		X		15		X		25		X		40		Higher than 40		
		Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	
Single	32	▽		0	1							1	2	2	3	3	4	5	6	7	8	8	9	10	11	12	13	14	15	18	19	21	22	△		32
Double	20	▽		*		Use Letter F		Use Letter J		Use Letter H		0	2	0	3	1	4	2	5	3	7	3	7	5	9		10	7	11	9	14	11	16	△		20
	40											1	2	3	4	4	5	6	7	8	9	11	12	12	13	15	16	18	19	23	24	26	27			40
Multiple	8	▽		*								•	2	•	2	•	3	•	4	0	4	0	4	0	5	0	6	1	7	1	8	2	9	△		8
	16											•	2	0	3	0	3	1	5	1	6	2	7	3	8	3	9	4	10	6	12	7	14			16
	24											0	2	0	3	1	4	2	6	3	8	4	9	6	10	7	12	8	13	11	17	13	19			24
	32											0	3	1	4	2	5	3	7	5	10	6	11	8	13	10	15	12	17	16	22	19	25			32
	40											1	3	2	4	3	6	5	8	7	11	9	12	11	15	14	17	17	20	22	25	25	29			40
	48											1	3	3	5	4	6	7	9	10	12	12	14	14	17	18	20	21	23	27	29	31	33			48
	56											2	3	4	5	6	7	9	10	13	14	14	15	18	19	21	22	25	26	32	33	37	38			56
		Less than 0.65		0.65		X		1.0		1.5		2.5		4.0		6.5		10		X		15		X		25		X		40		X		Higher than 40		
		Acceptable Quality Levels (tightened inspection)																																		

△ = Use next preceding sample size code letter for which acceptance and rejection numbers are available

▽ = Use next subsequent sample size code letter for which acceptance and rejection numbers are available

Ac = Acceptance number

Re = Rejection number

* = Use single sampling plan above (or alternatively use letter H)

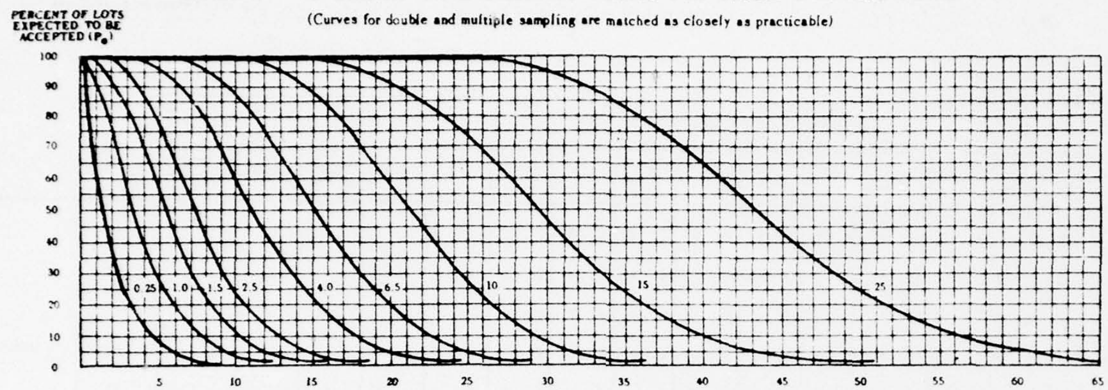
• = Acceptance not permitted at this sample size

G

TABLE X-H — Tables for sample size code letter: H

CHART H - OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

(Curves for double and multiple sampling are matched as closely as practicable)



QUALITY OF SUBMITTED LOTS (p, in percent defective for AQL's ≤ 10; in defects per hundred units for AQL's > 10)

Note: Figures on curves are Acceptable Quality Levels (AQL's) for normal inspection.

TABLE X-H-1 - TABULATED VALUES FOR OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

P_a	Acceptable Quality Levels (normal inspection)																			
	0.25	1.0	1.5	2.5	4.0	6.5		10	0.25	1.0	1.5	2.5	4.0	6.5		10		15		25
	p (in percent defective)								p (in defects per hundred units)											
99.0	0.020	0.306	0.888	1.69	3.66	6.06	7.41	11.1	0.020	0.298	0.872	1.65	3.57	5.81	7.01	9.54	12.2	15.0	20.7	25.1
95.0	0.103	0.712	1.66	2.77	5.34	8.20	9.74	12.9	0.103	0.710	1.64	2.73	5.23	7.96	9.39	12.3	15.4	18.5	24.9	29.8
90.0	0.210	1.07	2.23	3.54	6.42	9.53	11.2	14.5	0.210	1.06	2.20	3.49	6.30	9.31	10.9	14.0	17.3	20.6	27.3	32.5
75.0	0.574	1.92	3.46	5.09	8.51	12.0	13.8	17.5	0.576	1.92	3.45	5.07	8.44	11.9	13.7	17.2	20.8	24.5	31.8	37.4
50.0	1.38	3.33	5.31	7.30	11.3	15.2	17.2	21.2	1.39	3.36	5.35	7.34	11.3	15.3	17.3	21.6	25.3	29.3	37.3	43.3
25.0	2.74	5.30	7.70	10.0	14.5	18.8	21.0	25.2	2.77	5.39	7.84	10.2	14.8	19.4	21.6	26.0	30.4	34.8	43.5	49.9
10.0	4.50	7.56	10.3	12.9	17.8	22.4	24.7	29.1	4.61	7.78	10.6	13.4	18.6	23.5	26.0	30.8	35.6	40.3	49.5	56.4
5.0	5.82	9.13	12.1	14.8	19.9	24.7	27.0	31.6	5.99	9.49	12.6	15.5	21.0	26.3	28.9	33.9	38.9	43.8	53.4	60.5
1.0	8.80	12.5	15.9	18.8	24.3	29.2	31.7	36.3	9.21	13.3	16.8	20.1	26.2	32.0	34.8	40.3	45.6	50.9	61.1	68.7
	0.40	1.5	2.5	4.0	6.5		10		0.40	1.5	2.5	4.0	6.5		10		15		25	
	Acceptable Quality Levels (tightened inspection)																			

Note: Binomial distribution used for percent defective computations; Poisson for defects per hundred units

TABLE X-H-2 - SAMPLING PLANS FOR SAMPLE SIZE CODE LETTER: H

Type of sampling plan	Cumulative sample size	Less than 0.25 Ac Re	0.25 Ac Re	0.40 Ac Re	X Ac Re	0.65 Ac Re	1.0 Ac Re	1.5 Ac Re	2.5 Ac Re	4.0 Ac Re	6.5 Ac Re	X Ac Re	10 Ac Re	X Ac Re	15 Ac Re	X Ac Re	25 Ac Re	Higher than 25 Ac Re	Cumulative sample size
		Acceptable Quality Levels (normal inspection)																	
Single	50	▽	0 1	Use Letter G	Use Letter K	Use Letter J	1 2	2 3	3 4	5 6	7 8	8 9	10 11	12 13	14 15	18 19	21 22	△	50
Double	32	▽	•				0 2	0 3	1 4	2 5	3 7	3 7	5 9	6 10	7 11	9 14	11 16	△	32
	64						1 2	3 4	4 5	6 7	8 9	11 12	12 13	15 16	18 19	23 24	26 27		64
Multiple	13	▽	•				* 2	* 2	* 3	* 4	0 4	0 4	0 5	0 6	1 7	1 8	2 9	△	13
	26						* 2	0 3	0 3	1 5	1 6	2 7	3 8	3 9	4 10	6 12	7 14		26
	39						0 2	0 3	1 4	2 6	3 8	4 9	6 10	7 12	8 13	11 17	13 19		39
	52						0 3	1 4	2 5	3 7	5 10	6 11	8 13	10 15	12 17	16 22	19 25		52
	65						1 3	2 4	3 6	5 8	7 11	9 12	11 15	14 17	17 20	22 25	25 29		65
	78						1 3	3 5	4 6	7 9	10 12	12 14	14 17	18 20	21 23	27 29	31 33		78
	91						2 3	4 5	6 7	9 10	13 14	14 15	18 19	21 22	25 26	32 33	37 38		91
		Less than 0.40	0.40	X	0.65	1.0	1.5	2.5	4.0	6.5	X	10	X	15	X	25	X	Higher than 25	
		Acceptable Quality Levels (tightened inspection)																	

△ = Use next preceding sample size code letter for which acceptance and rejection numbers are available

▽ = Use next subsequent sample size code letter for which acceptance and rejection numbers are available

Ac = Acceptance number

Re = Rejection number

• = Use single sampling plan above (or alternatively use letter L)

* = Acceptance not permitted at this sample size

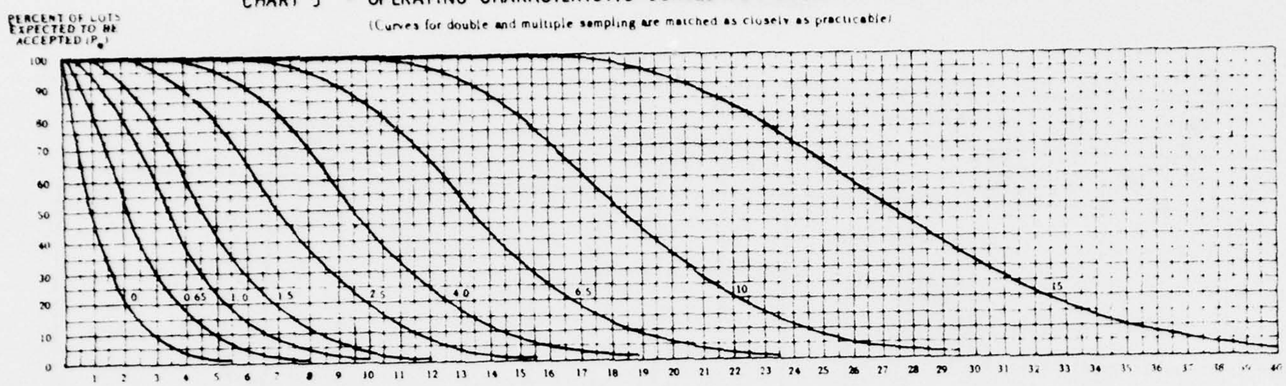
H

J

TABLE X-J—Tables for sample size code letter: J

CHART J - OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

(Curves for double and multiple sampling are matched as closely as practicable)



QUALITY OF SUBMITTED LOTS (p, in percent defective for AQL's ≤10, in defects per hundred units for AQL's >10)

Note: Figures on curves are Acceptable Quality Levels (AQL's) for normal inspection

TABLE X-J-1 - TABULATED VALUES FOR OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

P_a	Acceptable Quality Levels (normal inspection)																					
	0.15	0.65	1.0	1.5	2.5	4.0	X	6.5	X	10	0.15	0.65	1.0	1.5	2.5	4.0	X	6.5	X	10	X	15
	p (in percent defective)										p (in defects per hundred units)											
99.0	0.013	0.188	0.550	1.05	2.30	3.72	4.50	6.13	7.88	9.75	0.013	0.186	0.545	1.03	2.23	3.63	4.38	5.96	7.62	9.35	12.9	[illegible]
95.0	0.064	0.444	1.03	1.73	3.32	5.06	5.98	7.91	9.89	11.9	0.064	0.444	1.02	1.71	3.27	4.98	5.87	7.71	9.61	11.6	15.6	[illegible]
90.0	0.132	0.666	1.38	2.20	3.98	5.91	6.91	8.95	11.0	13.2	0.131	0.665	1.38	2.18	3.94	5.82	6.79	8.78	10.8	12.9	17.1	20.3
75.0	0.359	1.202	2.16	3.18	5.30	7.50	8.62	10.9	13.2	15.5	0.360	1.20	2.16	3.17	5.27	7.45	8.55	10.8	13.0	15.3	19.9	23.4
50.0	0.863	2.09	3.33	4.57	7.06	9.55	10.8	13.3	15.3	18.3	0.866	2.10	3.34	4.59	7.09	9.59	10.8	13.3	15.8	18.3	23.3	[illegible]
25.0	1.72	3.33	4.84	6.31	9.14	11.9	13.3	16.0	18.6	21.3	1.73	3.37	4.90	6.39	9.28	12.1	13.5	16.3	19.0	21.8	27.2	31.2
10.0	2.84	4.78	6.52	8.16	11.3	14.2	15.7	18.6	21.4	24.2	2.88	4.86	6.65	8.35	11.6	14.7	16.2	19.3	22.2	25.2	30.9	[illegible]
5.0	3.68	5.80	7.66	9.39	12.7	15.8	17.3	20.3	23.2	26.0	3.75	5.93	7.87	9.69	13.1	16.4	18.0	21.2	24.3	27.4	31.4	37.8
1.0	5.59	8.00	10.1	12.0	15.6	18.9	20.5	23.6	26.5	29.5	5.76	8.30	10.5	12.6	16.4	20.0	21.8	25.2	28.5	31.8	38.2	42.4
	0.25	1.0	1.5	2.5	4.0	X	6.5	X	10	X	0.25	1.0	1.5	2.5	4.0	X	6.5	X	10	X	15	X
	Acceptable Quality Levels (tightened inspection)																					

Note: All values given in above table based on Poisson distribution as an approximation to the Binomial.

TABLE X-J-2 - SAMPLING PLANS FOR SAMPLE SIZE CODE LETTER: J

Type of sampling plan	Cumulative sample size	Acceptable Quality Levels (normal inspection)																		Cumulative sample size
		Less than 0.15	0.15	0.25	X	0.40	0.65	1.0	1.5	2.5	4.0	X	6.5	X	10	X	15	Higher than 15		
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re		
Single	80	▽	0 1	Use Letter H	Use Letter L	Use Letter K	1 2	2 3	3 4	5 6	7 8	8 9	10 11	12 13	14 15	18 19	21 22	△		80
Double	50	▽	•				0 2	0 3	1 4	2 5	3 7	3 7	5 9	6 10	7 11	9 14	11 16	△		50
	100						1 2	3 4	4 5	6 7	8 9	11 12	12 13	15 16	18 19	23 24	26 27			100
Multiple	20	▽	•				* 2	* 2	* 3	* 4	0 4	0 4	0 5	0 6	1 7	1 8	2 9	△		20
	40						* 2	0 3	0 3	1 5	1 6	2 7	3 8	3 9	4 10	6 12	7 14			40
	60						0 2	0 3	1 4	2 6	3 8	4 9	6 10	7 12	8 13	11 17	13 19			60
	80						0 3	1 4	2 5	3 7	5 10	6 11	8 13	10 15	12 17	16 22	19 25			80
	100						1 3	2 4	3 6	5 8	7 11	9 12	11 15	14 17	17 20	22 25	25 29			100
	120						1 3	3 5	4 6	7 9	10 12	12 14	14 17	18 20	21 23	27 29	31 33			120
	140						2 3	4 5	6 7	9 10	13 14	14 15	18 19	21 22	25 26	32 33	37 38			140
		Less than 0.25	0.25	X	0.40	0.65	1.0	1.5	2.5	4.0	X	6.5	X	10	X	15	X	Higher than 15		
		Acceptable Quality Levels (tightened inspection)																		

△ = Use next preceding sample size code letter for which acceptance and rejection numbers are available.

▽ = Use next subsequent sample size code letter for which acceptance and rejection numbers are available.

Ac = Acceptance number

Re = Rejection number

• = Use single sampling plan above (or alternatively use letter M)

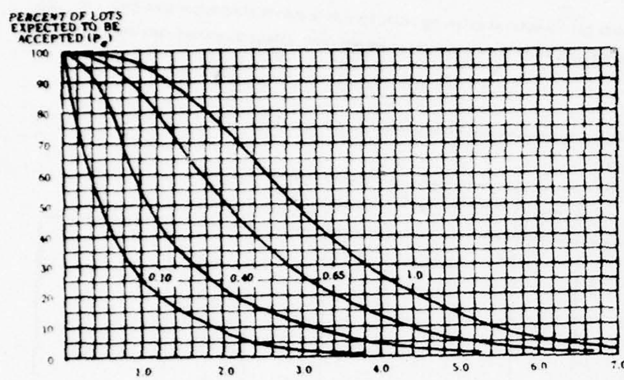
* = Acceptance not permitted at this sample size.

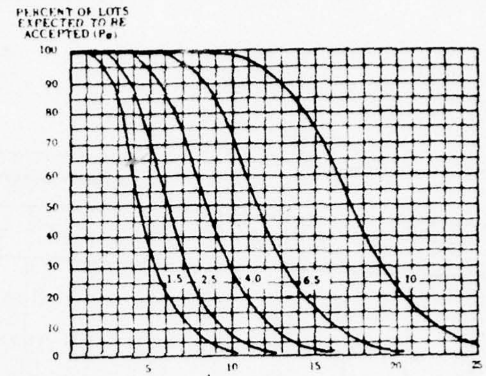
K

TABLE X-K—Tables for sample size code letter: K

CHART K - OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

(Curves for double and multiple sampling are matched as closely as practicable)





QUALITY OF SUBMITTED LOTS (p, in percent defective for AQL's $\leq$ 10; in defects per hundred units for AQL's $>$ 10)

Note: Figures on curves are Acceptable Quality Levels (AQL's) for normal inspection

TABLE X-K-1 - TABULATED VALUES FOR OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

P_a	Acceptable Quality Levels (normal inspection)											
	0.10	0.40	0.65	1.0	1.5	2.5	X	4.0	X	6.5	X	10
	p (in percent defective or defects per hundred units)											
99.0	0.0081	0.119	0.349	0.658	1.43	2.33	2.81	3.82	4.88	5.98	8.28	10.1
95.0	0.0410	0.284	0.654	1.09	2.09	3.19	3.76	4.94	6.15	7.40	9.95	11.9
90.0	0.0840	0.426	0.882	1.40	2.52	3.73	4.35	5.62	6.92	8.24	10.9	13.0
75.0	0.230	0.769	0.382	2.03	3.38	4.77	5.47	6.90	8.34	9.79	12.7	14.9
50.0	0.554	1.34	2.14	2.94	4.54	6.14	6.94	8.53	10.1	11.7	14.9	17.3
25.0	1.11	2.15	3.14	4.09	5.94	7.75	8.64	10.4	12.2	13.9	17.4	20.0
10.0	1.84	3.11	4.26	5.35	7.42	9.42	10.4	12.3	14.2	16.1	19.8	22.5
5.0	2.40	3.80	5.04	6.20	8.41	10.5	11.5	13.6	15.6	17.5	21.4	24.2
1.0	3.68	5.31	6.73	8.04	10.5	12.8	18.3	16.1	18.3	20.4	24.5	27.5
	0.15	0.65	1.0	1.5	2.5	X	4.0	X	6.5	X	10	X
	Acceptable Quality Levels (tightened inspection)											

Note: All values given in above table based on Poisson distribution as an approximation to the Binomial.

TABLE X-K-2 - SAMPLING PLANS FOR SAMPLE SIZE CODE LETTER: K

Type of sampling plan	Cumulative sample size	Acceptable Quality Levels (normal inspection): Less than 0.10	0.10	0.15	X	0.25	0.40	0.65	1.0	1.5	2.5	X	4.0	X	6.5	X	10	Higher than 10	Cumulative sample size
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	
Single	125	▽	0 1	Use Letter J	Use Letter M	Use Letter L	1 2	2 3	3 4	5 6	7 8	8 9	10 11	12 13	14 15	18 19	21 22	△	125
Double	80	▽	*				0 2	0 3	1 4	2 5	3 7	3 7	5 9	6 10	7 11	9 14	11 16	△	80
	160						1 2	3 4	4 5	6 7	8 9	11 12	12 13	15 16	18 19	23 24	26 27		160
Multiple	32	▽	*				# 2	# 2	# 3	# 4	0 4	0 4	0 5	0 6	1 7	1 8	2 9	△	32
	64						# 2	0 3	0 3	1 5	1 6	2 7	3 8	3 9	4 10	6 12	7 14		64
	96						0 2	0 3	1 4	2 6	3 8	4 9	6 10	7 12	8 13	11 17	13 19		96
	128						0 3	1 4	2 5	3 7	5 10	6 11	8 13	10 15	12 17	16 22	19 25		128
	160						1 3	2 4	3 6	5 8	7 11	9 12	11 15	14 17	17 20	22 25	25 29		160
	192						1 3	3 5	4 6	7 9	10 12	12 14	14 17	18 20	21 23	27 29	31 33		192
	224						2 3	4 5	6 7	9 10	13 14	14 15	18 19	21 22	25 26	32 33	37 38		224
	Acceptable Quality Levels (tightened inspection)	Less than 0.15	0.15	X	0.25	0.40	0.65	1.0	1.5	2.5	X	4.0	X	6.5	X	10	X	Higher than 10	

△ = Use next preceding sample size code letter for which acceptance and rejection numbers are available.

▽ = Use next subsequent sample size code letter for which acceptance and rejection numbers are available.

Ac = Acceptance number

Re = Rejection number

* = Use single sampling plan above (or alternatively use letter N)

\# = Acceptance not permitted at this sample size

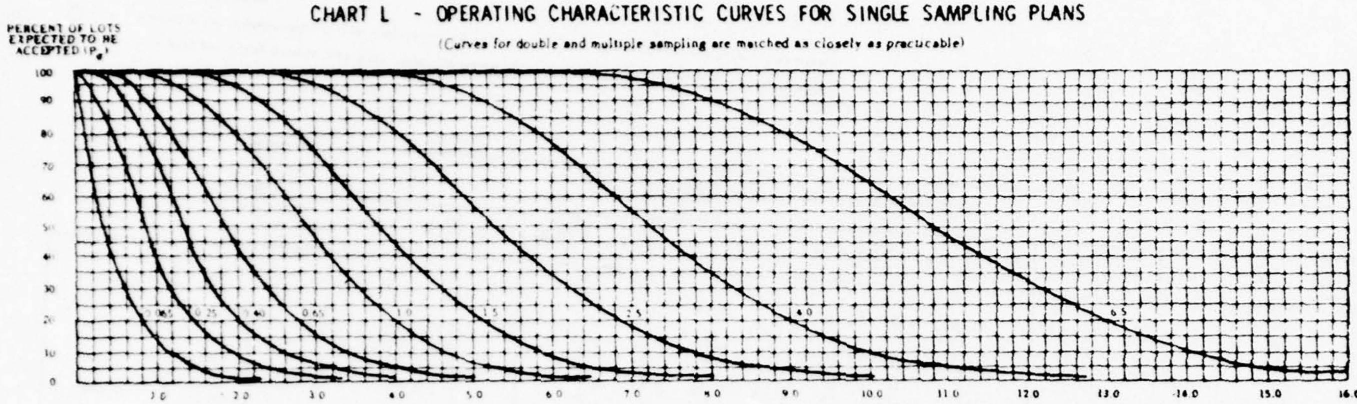
K

L

TABLE X-L—Tables for sample size code letter: L

CHART L - OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

(Curves for double and multiple sampling are matched as closely as practicable)



QUALITY OF SUBMITTED LOTS (p, in percent defective for AQL's ≤ 10; in defects per hundred units for AQL's > 10)

Note: Figures on curves are Acceptable Quality Levels (AQL's) for normal inspection

TABLE X-L-1 - TABULATED VALUES FOR OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

P_a	Acceptable Quality Levels (normal inspection)											
	0.065	0.25	0.40	0.65	1.0	1.5	X	2.5	X	4.0	X	6.5
	p (in percent defective or defects per hundred units)											
99.0	0.0051	0.075	0.218	0.412	0.893	1.45	1.75	2.39	3.05	3.74	5.17	6.29
95.0	0.0256	0.178	0.409	0.683	1.31	1.99	2.35	3.09	3.85	4.62	6.22	7.45
90.0	0.0525	0.266	0.551	0.873	1.58	2.33	2.72	3.51	4.32	5.15	6.84	8.12
75.0	0.144	0.481	0.864	1.27	2.11	2.98	3.42	4.31	5.21	6.12	7.95	9.34
50.0	0.347	0.839	1.34	1.84	2.84	3.84	4.33	5.33	6.33	7.33	9.33	10.8
25.0	0.693	1.35	1.96	2.56	3.71	4.84	5.40	6.51	7.61	8.70	10.9	12.5
10.0	1.15	1.95	2.66	3.34	4.64	5.89	6.50	7.70	8.89	10.1	12.4	14.1
5.0	1.50	2.37	3.15	3.88	5.26	6.57	7.22	8.48	9.72	10.9	13.3	15.1
1.0	2.30	3.32	4.20	5.02	6.55	8.00	8.70	10.1	11.4	12.7	15.3	17.2
	0.10	0.40	0.65	1.0	1.5	X	2.5	X	4.0	X	6.5	X
	Acceptable Quality Levels (tightened inspection)											

Note: All values given in above table based on Poisson distribution as an approximation to the Binomial.

TABLE X-L-2 - SAMPLING PLANS FOR SAMPLE SIZE CODE LETTER: L

Type of sampling plan	Cumulative sample size	Acceptable Quality Levels (normal inspection)																																		Cumulative sample size
		Less than 0.065		0.065		0.10				0.15		0.25		0.40		0.65		1.0		1.5				2.5				4.0				6.5		Higher than 6.5		
		Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	
Single	200	▽		0	1							1	2	2	3	3	4	5	6	7	8	8	9	10	11	12	13	14	15	18	19	21	22	△		200
Double	125	▽		•		Use Letter K		Use Letter N		Use Letter M		0	2	0	3	1	4	2	5	3	7	3	7	5	9	6	10	7	11	9	14	11	16	△		125
	250											1	2	3	4	4	5	6	7	8	9	11	12	12	13	15	16	18	19	23	24	26	27			250
Multiple	50	▽		•								*	2	*	2	*	3	*	4	0	4	0	4	0	5	0	6	1	7	1	8	2	9	△		50
	100											*	2	0	3	0	3	1	5	1	6	2	7	3	8	3	9	4	10	6	12	7	14			100
	150											0	2	0	3	1	4	2	6	3	8	4	9	6	10	7	12	8	13	11	17	13	19			150
	200											0	3	1	4	2	5	3	7	5	10	6	11	8	13	10	15	12	17	16	22	19	25			200
	250											1	3	2	4	3	6	5	8	7	11	9	12	11	15	14	17	17	20	22	25	25	29			250
	300											1	3	3	5	4	6	7	9	10	12	12	14	14	17	18	20	21	23	27	29	31	33			300
	350											2	3	4	5	6	7	9	10	13	14	14	15	18	19	21	22	25	26	32	33	37	38			350
		Less than 0.10		0.10				0.15		0.25		0.40		0.65		1.0		1.5				2.5				4.0				6.5				Higher than 6.5		
		Acceptable Quality Levels (tightened inspection)																																		

△ = Use next preceding sample size code letter for which acceptance and rejection numbers are available.

▽ = Use next subsequent sample size code letter for which acceptance and rejection numbers are available.

Ac = Acceptance number

Re = Rejection number

• = Use single sampling plan above (or alternatively use letter P).

* = Acceptance not permitted at this sample size.

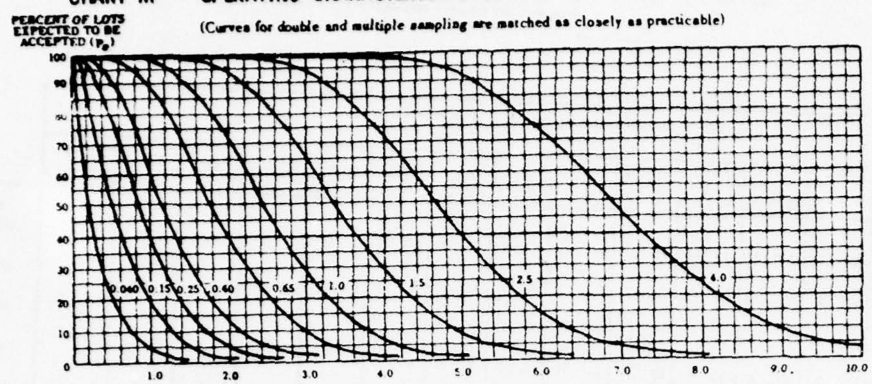
L

M

TABLE X-M—Tables for sample size code letter: M

CHART M - OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

(Curves for double and multiple sampling are matched as closely as practicable)



QUALITY OF SUBMITTED LOTS (p, in percent defective for AQL's ≤ 10; in defects per hundred units for AQL's > 10)

Note: Figures on curves are Acceptable Quality Levels (AQL's) for normal inspection.

TABLE X-M-1 - TABULATED VALUES FOR OPERATING CHARACTERSTIC CURVES FOR SINGLE SAMPLING PLANS

P_a	Acceptable Quality Levels (normal inspection)											
	0.040	0.15	0.25	0.40	0.65	1.0	X	1.5	X	2.5	X	4.0
	p (in percent defective or in defects per hundred units)											
99.0	0.0032	0.047	0.138	0.261	0.566	0.922	1.11	1.51	1.94	2.38	3.28	3.99
95.0	0.0163	0.112	0.259	0.433	0.829	1.26	1.49	1.96	2.44	2.94	3.95	4.73
90.0	0.0333	0.168	0.349	0.533	1.00	1.48	1.72	2.23	2.75	3.27	4.34	5.16
75.0	0.0914	0.305	0.580	0.804	1.34	1.89	2.17	2.74	3.31	3.89	5.05	5.93
50.0	0.220	0.532	0.848	1.17	1.80	2.43	2.75	3.39	4.02	4.66	5.93	6.88
25.0	0.440	0.854	1.24	1.62	2.36	3.07	3.43	4.13	4.83	5.52	6.90	7.92
10.0	0.731	1.23	1.69	2.12	2.94	3.74	4.13	4.89	5.65	6.39	7.86	8.95
5.0	0.951	1.51	2.00	2.46	3.34	4.17	4.58	5.38	6.17	6.95	8.47	9.60
1.0	1.46	2.11	2.67	3.19	4.16	5.08	5.53	6.40	7.25	8.08	9.71	10.9
	0.065	0.25	0.40	0.65	1.0	X	1.5	X	2.5	X	4.0	X
	Acceptable Quality Levels (tightened inspection)											

Note: All values given in above table based on Poisson distribution as an approximation to the Binomial

TABLE X-M-2 - SAMPLING PLANS FOR SAMPLE SIZE CODE LETTER: M

Type of sampling plan	Cumulative sample size	Acceptable Quality Levels (normal inspection): Less than 0.040	0.040	0.065	X	0.10	0.15	0.25	0.40	0.65	1.0	X	1.5	X	2.5	X	4.0	Higher than 4.0	Cumulative sample size
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	
Single	315	▽	0 1	Use Letter L	Use Letter P	Use Letter N	1 2	2 3	3 4	5 6	7 8	8 9	10 11	12 13	14 15	18 19	21 22	△	315
Double	200	▽	•				0 2	0 3	1 4	2 5	3 7	3 7	5 9	6 10	7 11	9 14	11 16	△	200
	400						1 2	3 4	4 5	6 7	8 9	11 12	12 13	15 16	18 19	23 24	26 27		400
Multiple	80	▽	•				* 2	* 2	* 3	* 4	0 4	0 4	0 5	0 6	1 7	1 8	2 9	△	80
	160						* 2	0 3	0 3	1 5	1 6	2 7	3 8	3 9	4 10	6 12	7 14		160
	240						0 2	0 3	1 4	2 6	3 8	4 9	6 10	7 12	8 13	11 17	13 19		240
	320						0 3	1 4	2 5	3 7	5 10	6 11	8 13	10 15	12 17	16 22	19 25		320
	400						1 3	2 4	3 6	5 8	7 11	9 12	11 15	14 17	17 20	22 25	25 29		400
	480						1 3	3 5	4 5	7 9	10 12	12 14	14 17	18 20	21 23	27 29	31 33		480
	560						2 3	4 5	6 7	9 10	13 14	14 15	18 19	21 22	25 26	32 33	37 38		560
	Acceptable Quality Levels (tightened inspection)	Less than 0.065	0.065	X	0.10	0.15	0.25	0.40	0.65	1.0	X	1.5	X	2.5	X	4.0	X	Higher than 4.0	

△ = Use next preceding sample size code letter for which acceptance and rejection numbers are available.

▽ = Use next subsequent sample size code letter for which acceptance and rejection numbers are available.

Ac = Acceptance number.

Re = Rejection number.

• = Use single sampling plan above (or alternatively use letter Q).

* = Acceptance not permitted at this sample size.

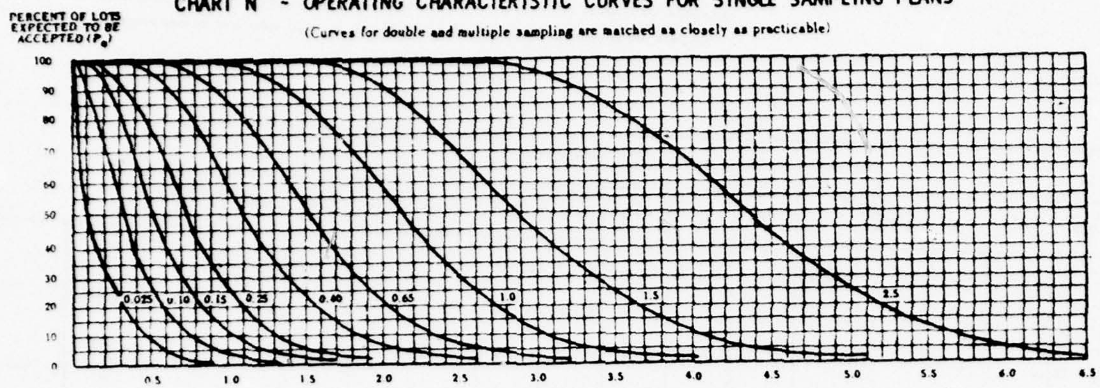
M

N

TABLE X-N — *Tables for sample size code letter: N*

CHART N - OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

(Curves for double and multiple sampling are matched as closely as practicable)



QUALITY OF SUBMITTED LOTS (p, in percent defective for AQL's ≤ 10; in defects per hundred units for AQL's > 10)

Note: Figures on curves are Acceptable Quality Levels (AQL's) for normal inspection.

TABLE X-N-1 - TABULATED VALUES FOR OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

P_a	Acceptable Quality Levels (normal inspection)											
	0.025	0.10	0.15	0.25	0.40	0.65	X	1.0	X	1.5	X	2.5
	p (in percent defective or in defects per hundred units)											
99.0	0.0020	0.030	0.087	0.165	0.357	0.581	0.701	0.954	1.22	1.50	2.07	2.51
95.0	0.0103	0.071	0.164	0.273	0.523	0.796	0.939	1.23	1.54	1.85	2.49	2.98
90.0	0.0210	0.106	0.220	0.349	0.630	0.931	1.09	1.40	1.73	2.06	2.73	3.25
75.0	0.0576	0.192	0.345	0.507	0.844	1.19	1.37	1.72	2.08	2.45	3.18	3.74
50.0	0.139	0.336	0.535	0.734	1.13	1.53	1.73	2.13	2.53	2.93	3.73	4.33
25.0	0.277	0.539	0.784	1.02	1.48	1.94	2.16	2.60	3.04	3.48	4.35	4.99
10.0	0.461	0.778	1.06	1.34	1.86	2.35	2.60	3.08	3.56	4.03	4.95	5.64
5.0	0.599	0.949	1.26	1.55	2.10	2.63	2.89	3.39	3.89	4.38	5.34	6.05
1.0	0.921	1.328	1.68	2.01	2.62	3.20	3.48	4.03	4.56	5.09	6.12	6.87
	0.040	0.15	0.25	0.40	0.65	X	1.0	X	1.5	X	2.5	X
	Acceptable Quality Levels (tightened inspection)											

Note: All values given in above table based on Poisson distribution as an approximation to the Binomial

TABLE X-N-2 - SAMPLING PLANS FOR SAMPLE SIZE CODE LETTER: N

Type of sampling plan	Cumulative sample size	Acceptable Quality Levels (normal inspection)																	Cumulative sample size
		Less than 0.025	0.025	0.040	×	0.065	0.10	0.15	0.25	0.40	0.65	×	1.0	×	1.5	×	2.5	Higher than 2.5	
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	
Single	500	▽	0 1	Use	Use	Use	1 2	2 3	3 4	5 6	7 8	8 9	10 11	12 13	14 15	18 19	21 22	△	500
Double	315	▽	•	Letter	Letter	Letter	0 2	0 3	1 4	2 5	3 7	3 7	5 9	6 10	7 11	9 14	11 16	△	315
	630			M	Q	P	1 2	3 4	4 5	6 7	8 9	11 12	12 13	15 16	18 19	23 24	26 27		630
Multiple	125	▽	•				# 2	# 2	# 3	# 4	0 4	0 4	0 5	0 6	1 7	1 8	2 9	△	125
	250						# 2	0 3	0 3	1 5	1 6	2 7	3 8	3 9	4 10	6 12	7 14		250
	375						0 2	0 3	1 4	2 6	3 8	4 9	6 10	7 12	8 13	11 17	13 19		375
	500						0 3	1 4	2 5	3 7	5 10	6 11	8 13	10 15	12 17	16 22	19 25		500
	625						1 3	2 4	3 6	5 8	7 11	9 12	11 15	14 17	17 20	22 25	25 29		625
	750						1 3	3 5	4 6	7 9	10 12	12 14	14 17	18 20	21 23	27 29	31 33		750
	875						2 3	4 5	6 7	9 10	13 14	14 15	18 19	21 22	25 26	32 33	37 38		875
		Less than 0.040	0.040	×	0.065	0.10	0.15	0.25	0.40	0.65	×	1.0	×	1.5	×	2.5	×	Higher than 2.5	
		Acceptable Quality Levels (tightened inspection)																	

△ = Use next preceding sample size code letter for which acceptance and rejection numbers are available.
▽ = Use next subsequent sample size code letter for which acceptance and rejection numbers are available.
Ac = Acceptance number
Re = Rejection number
• = Use single sampling plan above (or alternatively use letter R)
= Acceptance not permitted at this sample size

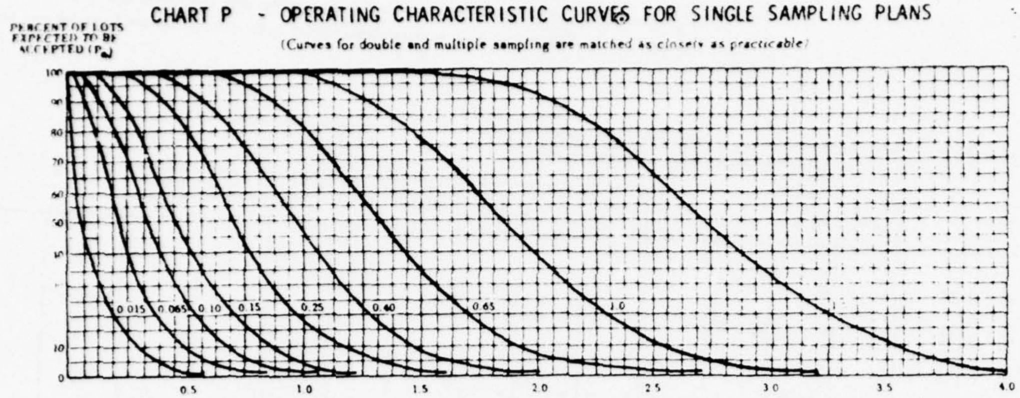
N

P

TABLE X-P—Tables for sample size code letter: P

CHART P - OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

(Curves for double and multiple sampling are matched as closely as practicable)



QUALITY OF SUBMITTED LOTS (p in percent defective for AQL's ≤ 10; in defects per hundred units for AQL's > 10)

Note: Figures on curves are Acceptable Quality Levels (AQL's) for normal inspection

TABLE X-P-1 - TABULATED VALUES FOR OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

P_a	Acceptable Quality Levels (normal inspection)											
	0.015	0.065	0.10	0.15	0.25	0.40	X	0.65	X	1.0	X	1.5
	p (in percent defective or defects per hundred units)											
99.0	0.0013	0.0186	0.055	0.103	0.223	0.363	0.438	0.596	0.762	0.935	1.29	1.57
95.0	0.0064	0.0444	0.102	0.171	0.327	0.498	0.587	0.771	0.961	1.16	1.56	1.86
90.0	0.0131	0.0665	0.138	0.218	0.394	0.582	0.679	0.878	1.08	1.29	1.71	2.03
75.0	0.0360	0.120	0.216	0.317	0.527	0.745	0.855	1.08	1.30	1.53	1.99	2.34
50.0	0.0866	0.210	0.334	0.459	0.709	0.959	1.08	1.33	1.58	1.83	2.33	2.71
25.0	0.173	0.337	0.490	0.639	0.928	1.21	1.35	1.63	1.90	2.18	2.72	3.12
10.0	0.288	0.486	0.665	0.835	1.16	1.47	1.62	1.93	2.22	2.52	3.09	3.52
5.0	0.375	0.593	0.787	0.969	1.31	1.64	1.80	2.12	2.43	2.74	3.34	3.78
1.0	0.576	0.830	1.05	1.26	1.64	2.00	2.18	2.52	2.85	3.18	3.82	4.29
	0.025	0.10	0.15	0.25	0.40	X	0.65	X	1.0	X	1.5	X
	Acceptable Quality Levels (tightened inspection)											

Note: All values given in above table based on Poisson distribution as an approximation to the Binomial

TABLE X-P-2 - SAMPLING PLANS FOR SAMPLE SIZE CODE LETTER: P

Type of sampling plan	Cumulative sample size	Acceptable Quality Levels (normal inspection) 0.010 Ac Re	0.015 Ac Re	0.025 Ac Re	X Ac Re	0.040 Ac Re	0.065 Ac Re	0.10 Ac Re	0.15 Ac Re	0.25 Ac Re	0.40 Ac Re	X Ac Re	0.65 Ac Re	X Ac Re	1.0 Ac Re	X Ac Re	1.5 Ac Re	Higher than 1.5 Ac Re	Cumulative sample size
Single	800	▽	0 1	Use	Use	Use	1 2	2 3	3 4	5 6	7 8	8 9	10 11	12 13	14 15	18 19	21 22	△	800
Double	500	▽	*	Letter	Letter	Letter	0 2	0 3	1 4	2 5	3 7	3 7	5 9	6 10	7 11	9 14	11 16	△	500
	1000			N	R	Q	1 2	3 4	4 5	6 7	8 9	11 12	12 13	15 16	18 19	23 24	26 27		1000
Multiple	200	▽	*				# 2	# 2	# 3	# 4	0 4	0 4	0 5	0 6	1 7	1 8	2 9	△	200
	400						# 2	0 3	0 3	1 5	1 6	2 7	3 8	3 9	4 10	6 12	7 14		400
	600						0 2	0 3	1 4	2 6	3 8	4 9	6 10	7 12	8 13	11 17	13 19		600
	800						0 3	1 4	2 5	3 7	5 10	6 11	8 13	10 15	12 17	16 22	19 25		800
	1000						1 3	2 4	3 6	5 8	7 11	9 12	11 15	14 17	17 20	22 25	25 29		1000
	1200						1 3	3 5	4 6	7 9	10 12	12 14	14 17	18 20	21 23	27 29	31 33		1200
	1400						2 3	4 5	6 7	9 10	13 14	14 15	18 19	21 22	25 26	32 33	37 38		1400
	Acceptable Quality Levels (tightened inspection)	Less than 0.025	0.025	X	0.040	0.065	0.10	0.15	0.25	0.40	X	0.65	X	1.0	X	1.5	X	Higher than 1.5	

△ = Use next preceding sample size code letter for which acceptance and rejection numbers are available.

▽ = Use next subsequent sample size code letter for which acceptance and rejection numbers are available.

Ac = Acceptance number.

Re = Rejection number.

* = Use single sampling plan above.

\# = Acceptance not permitted at this sample size.

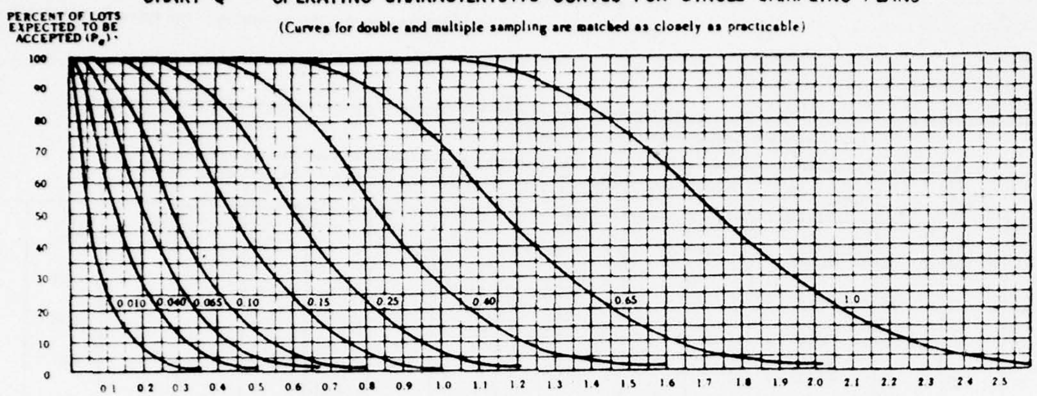
P

Q

TABLE X-Q—Tables for sample size code letter: Q

CHART Q - OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

(Curves for double and multiple sampling are matched as closely as practicable)



QUALITY OF SUBMITTED LOTS (p, in percent defective for AQL's ≤ 10; in defects per hundred units for AQL's > 10)

Note: Figures on curves are Acceptable Quality Levels (AQL's) for normal inspection

TABLE X-Q-1 - TABULATED VALUES FOR OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

P_a	Acceptable Quality Levels (normal inspection)											
	0.010	0.040	0.065	0.10	0.15	0.25	X	0.40	X	0.65	X	1.0
	p (in percent defective or defects per hundred units)											
99.0	0.00081	0.0119	0.0349	0.0656	0.143	0.232	0.281	0.382	0.488	0.598	0.828	1.01
95.0	0.00410	0.0284	0.0654	0.109	0.209	0.318	0.376	0.494	0.615	0.740	0.995	1.19
90.0	0.00840	0.0426	0.0862	0.140	0.252	0.372	0.435	0.562	0.692	0.824	1.09	1.30
75.0	0.0230	0.0769	0.138	0.203	0.338	0.476	0.547	0.690	0.834	0.979	1.27	1.49
50.0	0.0554	0.134	0.214	0.294	0.454	0.614	0.694	0.853	1.01	1.17	1.49	1.73
25.0	0.111	0.215	0.314	0.409	0.594	0.775	0.864	1.04	1.22	1.39	1.74	2.00
10.0	0.184	0.310	0.426	0.534	0.742	0.942	1.04	1.23	1.42	1.61	1.98	2.25
5.0	0.240	0.380	0.504	0.620	0.841	1.05	1.15	1.36	1.56	1.75	2.14	2.42
1.0	0.368	0.531	0.672	0.804	1.05	1.28	1.83	1.61	1.83	2.04	2.45	2.75
	0.015	0.065	0.10	0.15	0.25	X	0.40	X	0.65	X	1.0	X
	Acceptable Quality Levels (tightened inspection)											

Note: All values given in above table based on Poisson distribution as an approximation to the Binomial

TABLE X-Q-2 - SAMPLING PLANS FOR SAMPLE SIZE CODE LETTER: Q

Type of sampling plan	Cumulative sample size	Acceptable Quality Levels (normal inspection)																																				Cumulative sample size
		X		0.010		0.015		X		0.025		0.040		0.065		0.10		0.15		0.25		X		0.40		X		0.65		X		1.0		Higher than 1.0		
		Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	
Single	1250	Use Letter R		0	1	Use Letter P		Use Letter S		Use Letter R		1	2	2	3	3	4	5	6	7	8	8	9	10	11	12	13	14	15	18	19	21	22	△		1250
Double	800			•								0	2	0	3	1	4	2	5	3	7	3	7	5	9	6	10	7	11	9	14	11	16	△		800
	1600											1	2	3	4	4	5	6	7	8	9	11	12	12	13	15	16	18	19	23	24	26	27			1600
Multiple	315			•								#	2	#	2	#	3	#	4	0	4	0	4	0	5	0	6	1	7	1	8	2	9	△		315
	630											#	2	0	3	0	3	1	5	1	6	2	7	3	8	3	9	4	10	6	12	7	14			630
	945											0	2	0	3	1	4	2	6	3	8	4	9	6	10	7	12	8	13	11	17	13	19			945
	1260											0	3	1	4	2	5	3	7	5	10	6	11	8	13	10	15	12	17	16	22	19	25			1260
	1575											1	3	2	4	3	6	5	8	7	11	9	12	11	15	14	17	17	20	22	25	25	29			1575
	1890											1	3	3	5	4	6	7	9	10	12	12	14	14	17	18	20	21	23	27	29	31	33			1890
	2205											2	3	4	5	6	7	9	10	13	14	14	15	18	19	21	22	25	26	32	33	37	38			2205
		0.010		0.015		X		0.025		0.040		0.065		0.10		0.15		0.25		X		0.40		X		0.65		X		1.0		X		Higher than 1.0		
		Acceptable Quality Levels (tightened inspection)																																				

△ = Use next preceding sample size code letter for which acceptance and rejection numbers are available

Ac = Acceptance number

Re = Rejection number

• = Use single sampling plan above

= Acceptance not permitted at this sample size

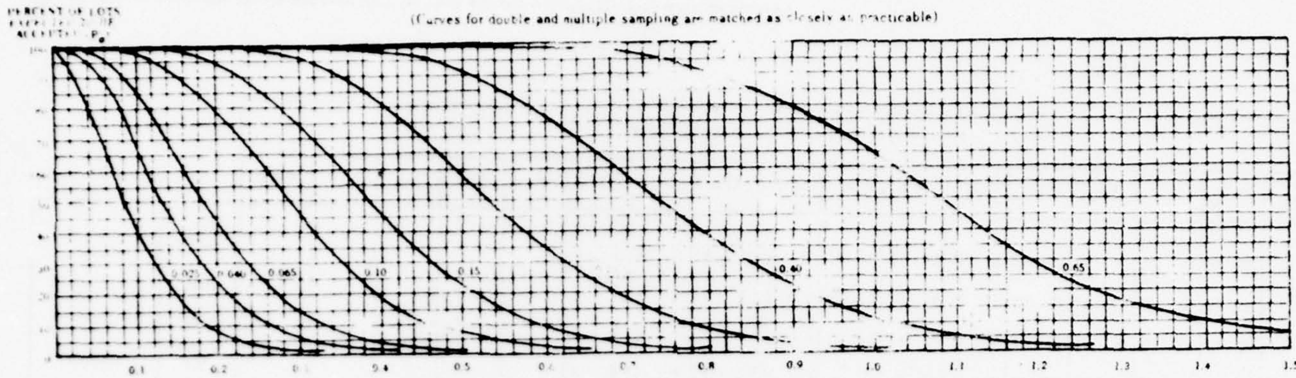
Q

R

TABLE X-R—Tables for sample size code letter: R

CHART R - OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

(Curves for double and multiple sampling are matched as closely as practicable)



QUALITY OF SUBMITTED LOTS (p, in percent defective for AQL's ≤ 10; in defects per hundred units for AQL's > 10)

Note: Figures on curves are Acceptable Quality Levels (AQL's) for normal inspection.

8

TABLE X-R-1 - TABULATED VALUES FOR OPERATING CHARACTERISTIC CURVES FOR SINGLE SAMPLING PLANS

P_a	Acceptable Quality Levels (normal inspection)										
	0.025	0.040	0.065	0.10	0.15	X	0.25	X	0.40	X	0.65
	p (in percent defective or defects per hundred units)										
99.0	0.0074	0.0218	0.0412	[illegible]	0.145	0.175	0.239	0.305	0.374	0.517	0.629
95.0	0.0178	0.0409	0.0683	0.131	0.199	0.235	0.309	0.385	0.462	0.622	0.745
90.0	[illegible]	0.0551	0.0873	0.158	0.233	0.272	0.351	0.432	0.515	0.684	0.812
75.0	0.0481	0.0868	0.127	0.211	0.298	[illegible]	0.431	0.521	0.612	0.795	0.934
50.0	0.0839	[illegible]	0.184	0.284	0.384	0.433	0.533	0.633	0.733	0.933	1.08
25.0	0.135	[illegible]	0.256	0.371	0.484	0.540	0.651	0.761	0.870	1.09	1.25
10.0	0.195	[illegible]	0.334	0.464	0.589	0.650	0.770	0.889	1.01	1.24	1.41
5.0	0.237	[illegible]	0.385	0.526	0.657	0.722	0.848	0.972	1.09	1.33	1.51
1.0	0.332	0.420	0.502	0.655	[illegible]	0.870	1.02	1.14	1.27	1.53	1.72
	0.040	0.065	0.10	0.15	X	0.25	X	0.40	X	0.65	X
	Acceptable Quality Levels (tightened inspection)										

Note: All values given in above table based on Poisson distribution as an approximation to the Binomial

TABLE X-R-2 - SAMPLING PLANS FOR SAMPLE SIZE CODE LETTER: R

Type of sampling plan	Cumulative sample size	Acceptable Quality Levels (normal inspection)																																		Cumulative sample size
		X		0.010		0.015		X		0.025		0.040		0.065		0.10		0.15		X		0.25		X		0.40		X		0.65		Higher than 0.65		
		Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	
Single	2000	0	1	Use Letter Q		Use Letter P		Use Letter S		1	2	2	3	3	4	5	6	7	8	8	9	10	11	12	13	14	15	18	19	21	22	△		2000
Double	1250	•								0	2	0	3	1	4	2	5	3	7	3	7	5	9	6	10	7	11	9	14	11	16	△		1250
	2500									1	2	3	4	4	5	6	7	8	9	11	12	12	13	15	16	18	19	23	24	26	27			2500
Multiple	500	•								#	2	#	2	#	3	#	4	0	4	0	4	0	5	0	6	1	7	1	8	2	9	△		500
	1000									#	2	0	3	0	3	1	5	1	6	2	7	3	8	3	9	4	10	6	12	7	14			1000
	1500									0	2	0	3	1	4	2	6	3	8	4	9	6	10	7	12	8	13	11	17	13	19			1500
	2000									0	3	1	4	2	5	3	7	5	10	6	11	8	13	10	15	12	17	16	22	19	25			2000
	2500									1	3	2	4	3	6	5	8	7	11	9	12	11	15	14	17	17	20	22	25	25	29			2500
	3000									1	3	3	5	4	6	7	9	10	12	12	14	14	17	18	20	21	23	27	29	31	33			3000
	3500									2	3	4	5	6	7	9	10	13	14	14	15	18	19	21	22	25	26	32	33	37	38			3500
		0.010		0.015		X		0.025		0.040		0.065		0.10		0.15		X		0.25		X		0.40		X		0.65		X		Higher than 0.65		
		Acceptable Quality Levels (tightened inspection)																																		

△ = Use next preceding sample size code letter for which acceptance and rejection numbers are available.
Ac = Acceptance number.
Re = Rejection number.
• = Use single sampling plan above.
= Acceptance not permitted at this sample size.

R

S

TABLE X-S—Tables for sample size code letter: S

Type of sampling plan	Cumulative sample size	Acceptable Quality Level (normal inspection)	
		X	
		Ac	Re
Single	3150	1	2
Double	2000	0	2
	4000	1	2
Multiple	800	#	2
	1600	#	2
	2400	0	2
	3200	0	3
	4000	1	3
	4800	1	3
	5600	2	3
		0.025	
		Acceptable Quality Level (tightened inspection)	

Ac = Acceptance number
Re = Rejection number
# = Acceptance not permitted at this sample size.

Index of terms with special meanings

Copies of this standard may be obtained by directing requests to:

Commanding Officer
U.S. Naval Supply Depot
ATTN: Code DMD
5801 Tabor Avenue
Philadelphia 20, Pennsylvania

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Custodians:

Army - Munitions Command
Navy - Bureau of Weapons
Air Force - Air Force Logistics Command
Defense Supply Agency

Preparing Activity:

Army - Munitions Command

SPECIFICATION ANALYSIS SHEET	Form Approved Budget Bureau No. 119-R004

INSTRUCTIONS

This sheet is to be filled out by personnel either Government or contractor, involved in the use of the specification in procurement of products for ultimate use by the Department of Defense. This sheet is provided for obtaining information on the use of this specification which will insure that suitable products can be procured with a minimum amount of delay and at the least cost. Comments and the return of this form will be appreciated. Fold on lines on reverse side, staple in corner, and send to preparing activity *(as indicated on reverse hereof)*.

SPECIFICATION

ORGANIZATION *(Of submitter)* | CITY AND STATE

CONTRACT NO. | QUANTITY OF ITEMS PROCURED | DOLLAR AMOUNT $

MATERIAL PROCURED UNDER A

☐ DIRECT GOVERNMENT CONTRACT ☐ SUBCONTRACT

1. HAS ANY PART OF THE SPECIFICATION CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?

A. GIVE PARAGRAPH NUMBER AND WORDING.

B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES.

2. COMMENTS ON ANY SPECIFICATION REQUIREMENT CONSIDERED TOO RIGID

3. IS THE SPECIFICATION RESTRICTIVE?

☐ YES ☐ NO IF "YES", IN WHAT WAY?

4. REMARKS *(Attach any pertinent data which may be of use in improving this specification. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity)*

SUBMITTED BY *(Printed or typed name and activity)* | DATE

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MIL-STD-414
NOTICE 1
8 MAY 1968

MILITARY STANDARD

SAMPLING PROCEDURES AND TABLES
FOR INSPECTION BY VARIABLES
FOR PERCENT DEFECTIVE

TO ALL HOLDERS OF MIL-STD-414:

1. The following changes shall be made in pen and ink:
   a. page 98, Example D-4 under Example line 8: change "65,500" to "60,500"
   b. page 98, Example D-4 under Example line 9: change "68,000 to "63,000"

2. Add "FSC MISC" on bottom of cover sheet.

3. Retain this notice and insert before the table of contents.

4. Holders of MIL-STD-414 will verify that changes indicated above have been entered. This notice will be retained as a check sheet. This issuance is a separate publication. Each notice is to be retained by stacking points until the Military Standard is completely revised or cancelled.

(Project MISC-0538)

U.S. GOVERNMENT PRINTING OFFICE: 1972-714-162/4829

MIL-STD-414
11 June 1957

SUPERSEDING
ORD-M608-10
June 1954
NAVORD OSTD 80
8 May 1952

MILITARY STANDARD

SAMPLING PROCEDURES AND TABLES FOR INSPECTION BY VARIABLES FOR PERCENT DEFECTIVE

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE
Washington 25, D. C.

Supply and Logistics 11 June 1957

Sampling Procedures and Tables for Inspection by
Variables for Percent Defective
MIL-STD-414

1. This standard has been approved by the Department of Defense and is mandatory for use by the Departments of the Army, the Navy, and the Air Force, effective 11 June 1957.

2. In accordance with established procedure, the Standardization Division has designated the Chemical Corps, Bureau of Ordnance, and Air Force, respectively, as Army-Navy-Air Force custodians of this standard.

3. Recommended corrections, additions, or deletions should be addressed to the Standardization Division, Office of the Assistant Secretary of Defense (Supply and Logistics), Washington 25, D. C.

CONTENTS

CONTENTS—Continued

CONTENTS—Continued

INTRODUCTION

This Standard was prepared to meet a growing need for the use of standard sampling plans for inspection by variables in Government procurement, supply and storage, and maintenance inspection operations. The variables sampling plans apply to a single quality characteristic which can be measured on a continuous scale, and for which quality is expressed in terms of percent defective. The theory underlying the development of the variables sampling plans, including the operating characteristic curves, assumes that measurements of the quality characteristic are independent, identically distributed normal random variables.

In comparison with attributes sampling plans, variables sampling plans have the advantage of usually resulting in considerable savings in sample size for comparable assurance as to the correctness of decisions in judging a single quality characteristic, or for the same sample size, greater assurance is obtained using variables plans. Attributes sampling plans have the advantage of greater simplicity, of being applicable to either single or multiple quality characteristics, and of requiring no knowledge about the distribution of the continuous measurements of any of the quality characteristics.

It is important to note that variables sampling plans are not to be used indiscriminately, simply because it is possible to obtain variables measurement data. In considering applications where the normality or independence assumptions may be questioned, the user is advised to consult his technical agency to determine the feasibility of application.

This Standard is divided into four sections. Section A describes general procedures of the sampling plans. Sections B and C describe specific procedures and applications of the sampling plans when variability is unknown. In Section B the estimate of lot standard deviation is used as the basis for an estimate of the unknown variability, and in Section C the average range of the sample is used. Section D describes the plans when variability is known.

Each of Sections B, C, and D is divided into three parts: (I) Sampling Plans for the Single Specification Limit Case, (II) Sampling Plans for the Double Specification Limit Case, and (III) Procedures for Estimation of Process Average and Criteria for Tightened and Reduced Inspection. For the single specification limit case, the acceptability criterion is given in two forms: Form 1 and Form 2. Either of the forms may be used, since they are identical as to sample size and decision for lot acceptability or rejectability. In deciding whether to use Form 1 or Form 2, the following points should be borne in mind. Form 1 provides the lot acceptability criterion without estimating lot percent defective. The Form 2 lot acceptability criterion requires estimates of lot percent defective. These estimates also are required for estimation of the process average.

Operating Characteristic Curves in Table A-3 show the relationship between quality and percent of lots expected to be acceptable for the quality characteristic inspected. As stated, these Operating Characteristic Curves are based on the assumption that measurements are selected at random from a normal distribution.

The corresponding sampling plans in Sections B, C, and D were matched as closely as possible under a system of fixed sample size with respect to their Operating Characteristic Curves. Operating Characteristic Curves in Table A-3 have been computed for the sampling plans based on the estimate of lot standard deviation of unknown variability. They are equally applicable for sampling plans based on the average range of the sample of unknown variability and those based on known variability.

Certain characteristics concerning the sampling plans in Sections B and C and those in Section D should be noted. Plans based on the estimate of unknown variability require fewer sample units for comparable assurance when the estimate of lot standard deviation is used than when the average range of the sample is used; on the other hand, plans using the average range of the sample require

simpler computations. Plans using known variability require considerably fewer sample units for comparable assurance than either of the plans when variability is unknown; however, the requirement of known variability is a stringent one. The user is advised to consult his technical agency before applying sampling plans using known variability.

Table B-8 provides values of the factor F to compute the maximum standard deviation MSD. The MSD serves as a guide for the magnitude of the estimate of lot standard deviation when using plans for the double specification limit case, based on the estimate of lot standard deviation of unknown variability. Similarly Table C-8 provides values of the factor f to compute the maximum average range MAR. The MAR serves as a guide for the magnitude of the average range of the sample when using plans for the double specification limit case, based on the average range of the sample of unknown variability. The estimate of lot standard deviation or average range of the sample, if it is less than the MSD or MAR, respectively, helps to insure, but does not guarantee, lot acceptability.

All symbols and their definitions are given in the appendix to Part III of the applicable section. An illustration of the computations and procedures used in the sampling plans is given in the examples of Parts I and II of the applicable section. The computations involve simple arithmetic operations such as addition, subtraction, multiplication, and division of numbers, or at most, the taking of a square root of a number. The user should become familiar with the general procedures of Section A, and refer to the applicable section for detailed instructions regarding specific procedures, computations, and tables for the sampling plans.

SECTION A

GENERAL DESCRIPTION OF SAMPLING PLANS

A1. SCOPE

A1.1 Purpose. This Standard establishes sampling plans and procedures for inspection by variables for use in Government procurement, supply and storage, and maintenance inspection operations. When applicable this Standard shall be referenced in the specification, contract, or inspection instructions, and the provisions set forth herein shall govern.

A1.2 Inspection. Inspection is the process of measuring, examining, testing, gaging, or otherwise comparing the "unit of product" (See A1.4) with the applicable requirements.

A1.3 Inspection by Variables. Inspection by variables is inspection wherein a specified quality characteristic (See A1.5) on a unit of product is measured on a continuous scale, such as pounds, inches, feet per second, etc., and a measurement is recorded.

A1.4 Unit of Product. The unit of product is the entity of product inspected in order to determine its measurable quality characteristic. This may be a single article, a pair, a set, a component of an end product, or the end product itself. The unit of product may or may not be the same as the unit of purchase, supply, production, or shipment.

A1.5 Quality Characteristic. The quality characteristic for variables inspection is that characteristic of a unit of product that is actually measured, to determine conformance with a given requirement.

A1.6 Specification Limits. The specification limit(s) is the requirement that a quality characteristic should meet. This requirement may be expressed as an upper specification limit; or a lower specification limit, called herein a single specification limit; or both upper and lower specification limits, called herein a double specification limit.

A1.7 Sampling Plans. A sampling plan is a procedure which specifies the number of units of product from a lot which are to be inspected, and the criterion for acceptability of the lot. Sampling plans designated in this Standard are applicable to the inspection of a single quality characteristic of a unit of product. These plans may be used whether procurement inspection is performed at the plant of a prime contractor, subcontractor or vendor, or at destination, and also may be used when appropriate in supply and storage, and maintenance inspection operations.

A2. CLASSIFICATION OF DEFECTS

A2.1 Method of Classifying Defects. A classification of defects is the enumeration of defects of the unit of product classified according to their importance. A defect is a deviation of the unit of product from requirements of the specifications, drawings, purchase descriptions, and any changes thereto in the contract or order. Defects normally belong to one of the following classes; however, defects may be placed in other classes.

A2.1.1 Critical Defects. A critical defect is one that judgment and experience indicate could result in hazardous or unsafe conditions for individuals using or maintaining the product; or, for major end items units of product, such as ships, aircraft, or tanks, a defect that could prevent performance of their tactical function.

A2.1.2 Major Defects. A major defect is a defect, other than critical, that could result in failure, or materially reduce the usability of the unit of product for its intended purpose.

A2.1.3 Minor Defects. A minor defect is one that does not materially reduce the usability of the unit of product for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit.

A3. PERCENT DEFECTIVE

A3.1 Expression of Nonconformance. The extent of nonconformance of product shall be expressed in terms of percent defective.

A3.2 Percent Defective. The percent defective for a quality characteristic of a given lot of product is the number of units of product defective for that characteristic divided by the total number of units of product and multiplied by one hundred. Expressed as an equation: Percent defective =

$$\frac{\text{Number of defectives} \times 100}{\text{Number of units}}$$

A4. ACCEPTABLE QUALITY LEVEL

A4.1 Acceptable Quality Level. The acceptable quality level (AQL) is a nominal value expressed in terms of percent defective specified for a single quality characteristic. Certain numerical values of AQL ranging from .04 to 15.00 percent are shown in Table A-1. When a range of AQL values is specified, it shall be treated as if it were equal to the value of AQL for which sampling plans are furnished and which is included within the AQL range. When the specified AQL is a particular value other than those for which sampling plans are furnished, the AQL, which is to be used in applying the provisions of this Standard, shall be as shown in Table A-1.

A4.2 Specifying AQL's. The particular AQL value to be used for a single quality characteristic of a given product must be specified. In the case of a double specification limit, either an AQL value is specified for the total percent defective outside of both upper and lower specification limits, or two AQL values are specified, one for the upper limit and another for the lower limit.

A5. SUBMITTAL OF PRODUCT

A5.1 Lot. The term "lot" shall mean "inspection lot," i.e., a collection of units of product from which a sample is drawn and inspected to determine compliance with the acceptability criterion.

A5.1.1 Formation of Lots. Each lot shall, as far as is practicable, consist of units of product of a single type, grade, class, size, or composition manufactured under essentially the same conditions.

A5.2 Lot Size. The lot size is the number of units of product in a lot, and may differ from the quantity designated in the contract or order as a lot for production, shipment, or other purposes.

A6. LOT ACCEPTABILITY

A6.1 Acceptability Criterion. The acceptability of a lot of material submitted for inspection shall be determined by use of one of the sampling plans associated with a specified value of the AQL(s). This Standard provides sampling plans based on known and unknown variability. In the latter case two alternative methods are provided, one based on the estimate of lot standard deviation and the other on the average range of the sample. These are referred to as the standard deviation method and the range method. For the case of a single specification limit, the acceptability criterion is given in two forms. These are identified as Form 1 and Form 2.

A6.2 Choice of Sampling Plans. Sampling plans and procedures are provided in Section B if variability is unknown and the standard deviation method is used, in Section C if variability is unknown and the range method is used, and in Section D if variability is known. Unless otherwise specified, unknown variability, standard deviation method sampling plans, and the acceptability criterion of Form 2 (for the single specification limit case) shall be used.

A7. SAMPLE SELECTION

A7.1 Determination of Sample Size. The sample size is the number of units of product drawn from a lot. Relative sample sizes are designated by code letters. The sample size code letter depends on the inspection level and the lot size. There are five inspection levels: I, II, III, IV, and V. Unless otherwise specified inspection level IV shall be used. The sample size code letter applicable to the specified inspection level and for lots of given size shall be obtained from Table A-2.

NOTICE—Special Reservation for Critical Characteristics. The Government reserves the right to inspect every unit submitted by the supplier for critical characteristics, and to reject the remainder of the lot immediately after a defect is found. The Government also reserves the right to sample for critical defects every lot submitted by the supplier and to reject any lot if a sample drawn therefrom is found to contain one or more critical defects.

A7.2 Drawing of Samples. A sample is one or more units of product drawn from a lot. Units of the sample shall be selected without regard to their quality.

A8. ESTIMATION OF PROCESS AVERAGE AND SEVERITY OF INSPECTION

Procedures for estimating the process average and criteria for tightened and reduced inspection based on the inspection results of preceding lots are provided in Part III of Sections B, C, and D.

A9. SPECIAL PROCEDURE FOR APPLICATION OF MIXED VARIABLES-ATTRIBUTES SAMPLING PLANS

A9.1 Applicability. A mixed variables and attributes sampling plan may be used under either of the two following conditions: (NOTE: No Operating Characteristic Curves

are provided for the mixed variables-attributes sampling plans herein and that those in Table A-3 are not applicable.)

Condition A. Ample evidence exists that the product submitted for inspection is selected by the supplier to meet the specification limit(s) by a screening process from a larger quantity of product which is not being produced within the specification limit(s).

Condition B. Other conditions exist that warrant the use of a variables-attributes sampling plan.

A9.2 Definitions.

A9.2.1 *Inspection by Attributes.* Inspection by attributes is inspection wherein the unit of product is classified simply as defective or nondefective with respect to a given requirement or set of requirements.

A9.2.2 Mixed Variables-Attributes Inspection. *Mixed variables-attributes inspection* is inspection of a sample by attributes, in addition to inspection by variables already made of a previous sample, before a decision as to acceptability or rejectability of a lot can be made.

A9.3 Selection of Sampling Plans. The mixed variables-attributes sampling plan shall be selected in accordance with the following:

A9.3.1 Select the variables sampling plan in accordance with Section B, C, or D.

A9.3.2 Select the attributes sampling plan from MIL-STD-105, paragraph 10, using a single sampling plan and tightened inspection. The same AQL value(s) shall be used for the attributes sampling plan as used for the variables plan of paragraph A9.3.1. (Additional sample items may be drawn, as necessary, to satisfy the requirements for sample size of the attributes sampling plan. Count as a defective each sample item falling outside of specification limit(s).)

A9.4 Determination of Acceptability. A lot meets the acceptability criterion if one of the following conditions is satisfied:

Condition A. The lot complies with the appropriate variables acceptability criterion of Section B, C, or D.

Condition B. The lot complies with the acceptability criterion of paragraph 11.1.2 of MIL-STD-105.

A9.4.1 If Condition A is not satisfied, proceed in accordance with the attributes sampling plan to meet Condition B.

A9.4.2 If Condition B is not satisfied, the lot does not meet the acceptability criterion.

A9.5 Severity of Inspection. The procedures for severity of inspection referred to in paragraph A8 are not applicable for mixed variables-attributes inspection.

TABLE A-1

AQL Conversion Table

For specified AQL values falling within these ranges	Use this AQL value
—— to 0.049	0.04
0.050 to 0.069	0.065
0.070 to 0.109	0.10
0.110 to 0.164	0.15
0.165 to 0.279	0.25
0.280 to 0.439	0.40
0.440 to 0.699	0.65
0.700 to 1.09	1.0
1.10 to 1.64	1.5
1.65 to 2.79	2.5
2.80 to 4.39	4.0
4.40 to 6.99	6.5
7.00 to 10.9	10.0
11.00 to 16.4	15.0

TABLE A-2

Sample Size Code Letters[1]

Lot Size	Inspection Levels				
	I	II	III	IV	V
3 to 8	B	B	B	B	C
9 to 15	B	B	B	B	D
16 to 25	B	B	B	C	E
26 to 40	B	B	B	D	F
41 to 65	B	B	C	E	G
66 to 110	B	B	D	F	H
111 to 180	B	C	E	G	I
181 to 300	B	D	F	H	J
301 to 500	C	E	G	I	K
501 to 800	D	F	H	J	L
801 to 1,300	E	G	I	K	L
1,301 to 3,200	F	H	J	L	M
3,201 to 8,000	G	I	L	M	N
8,001 to 22,000	H	J	M	N	O
22,001 to 110,000	I	K	N	O	P
110,001 to 550,000	I	K	O	P	Q
550,001 and over	I	K	P	Q	Q

[1]Sample size code letters given in body of table are applicable when the indicated inspection levels are to be used.

TABLE A-3

Operating Characteristic Curves for Sampling Plans of Sections B, C, and D

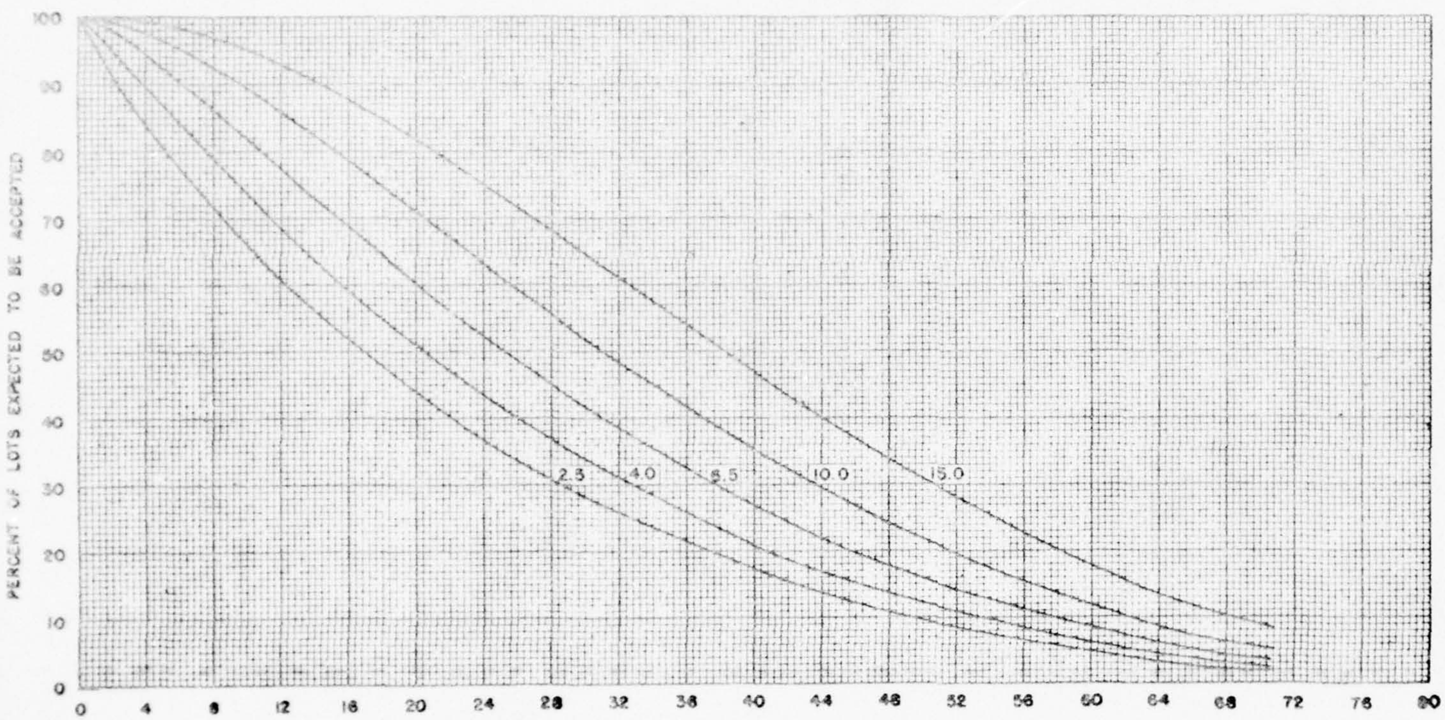
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

B

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

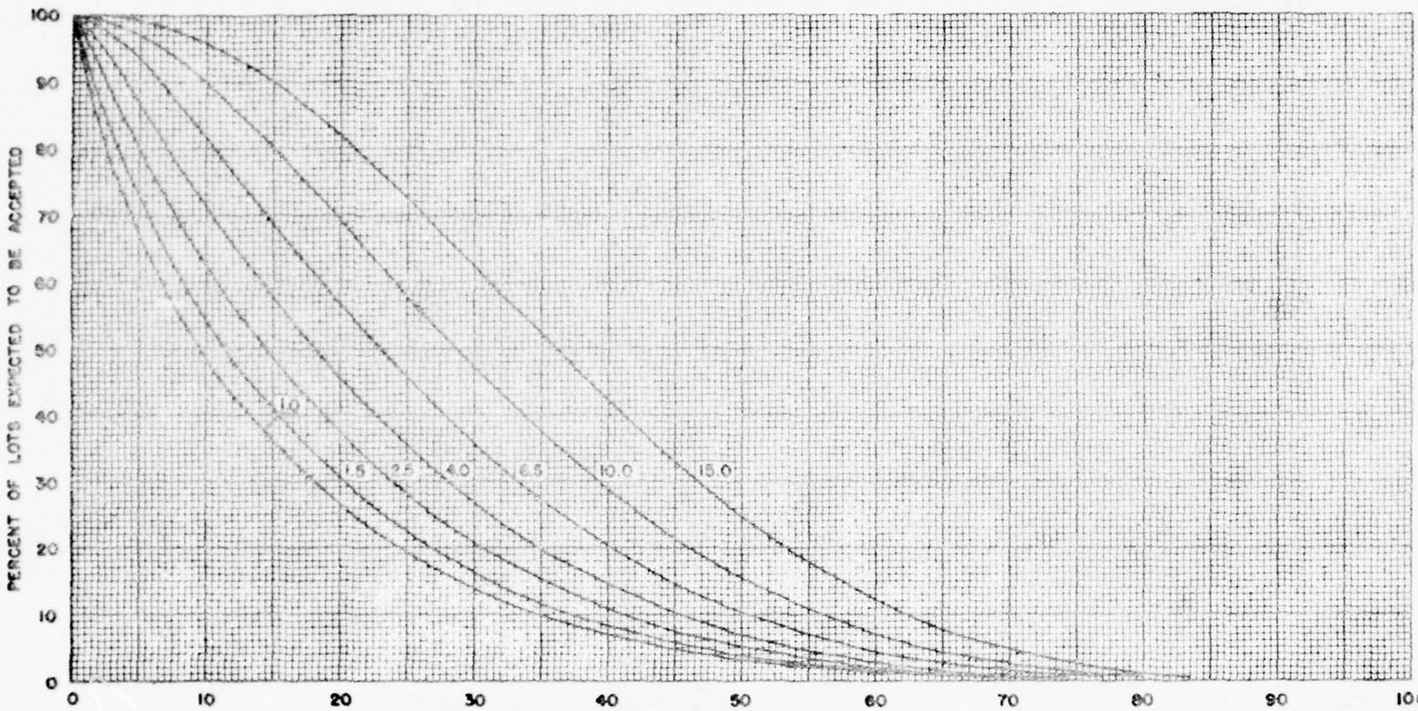
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

C

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

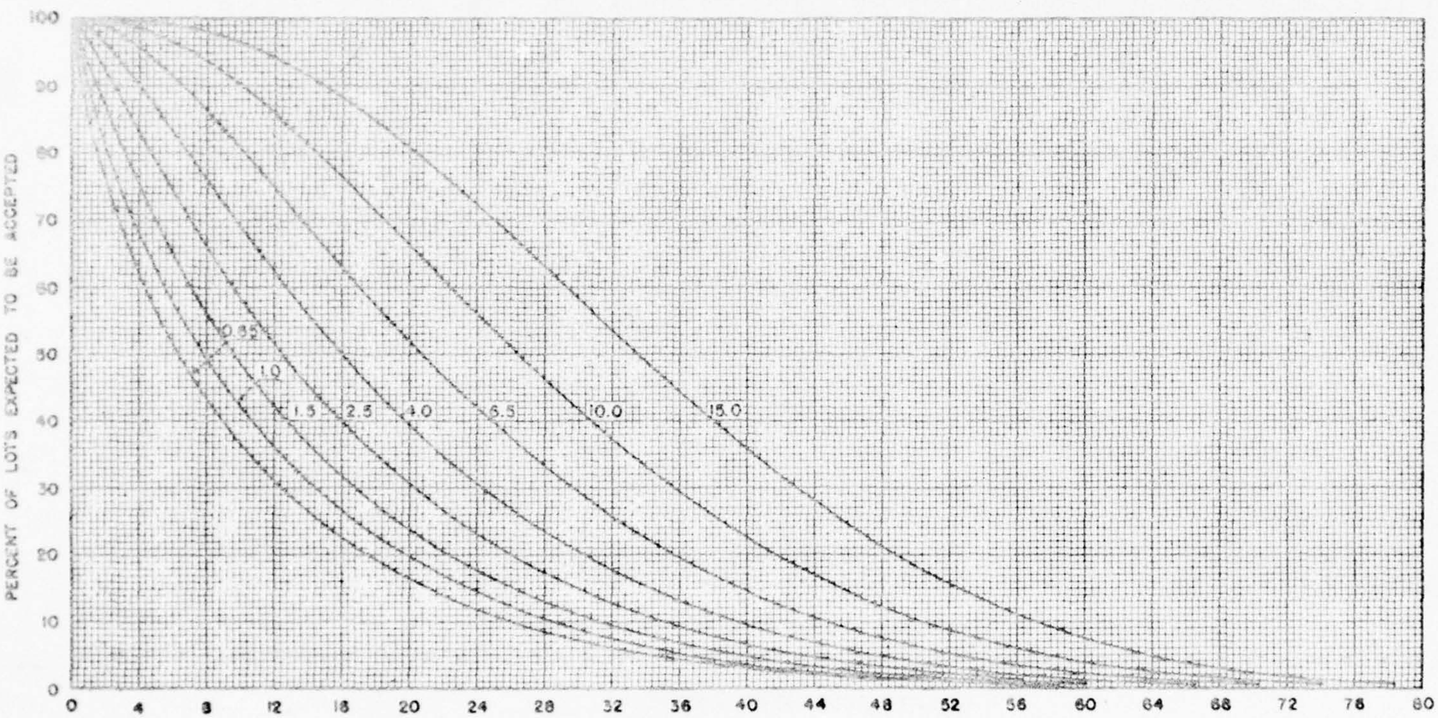
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

D

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (in percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

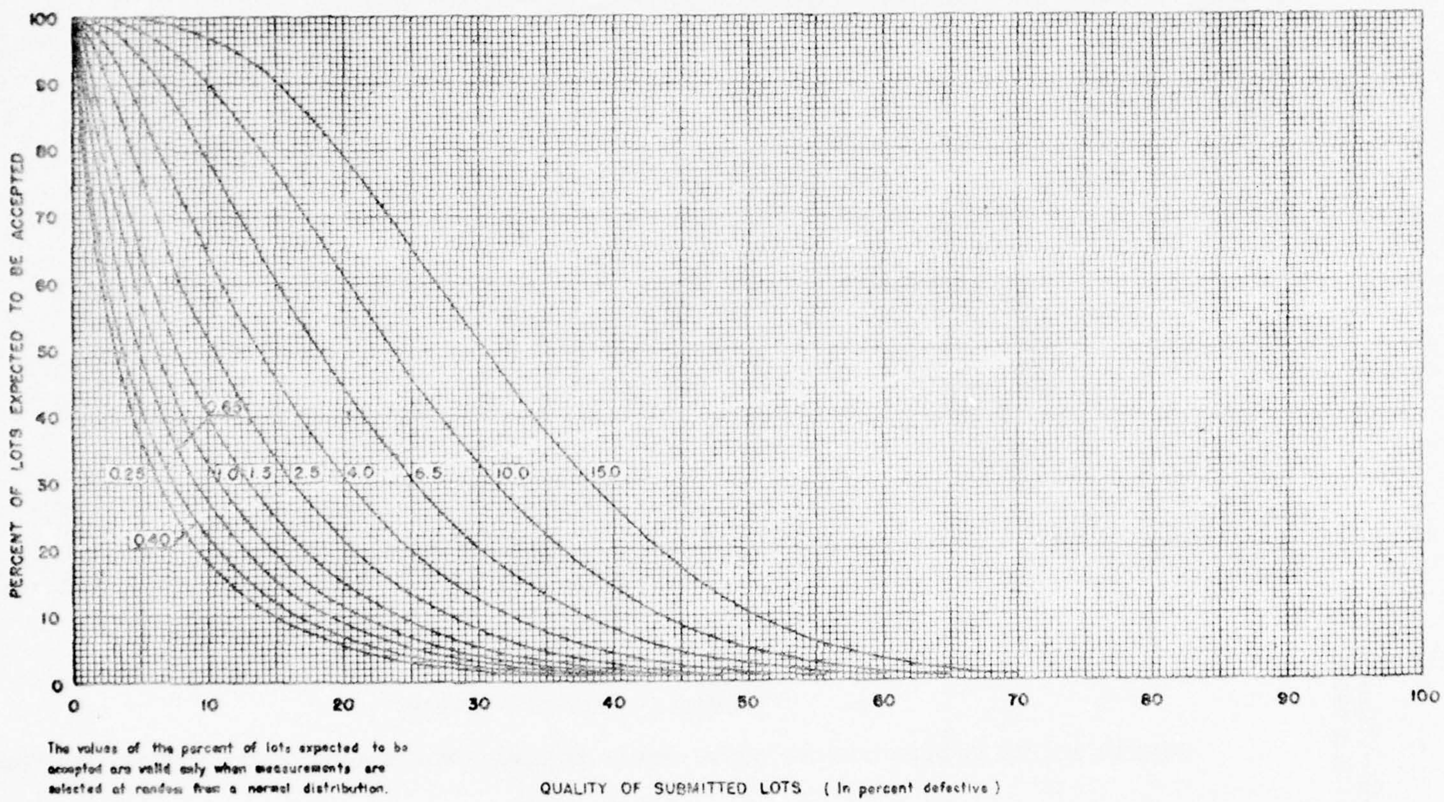
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

E

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

Note: Figures on curves are Acceptable Quality Levels for normal inspection

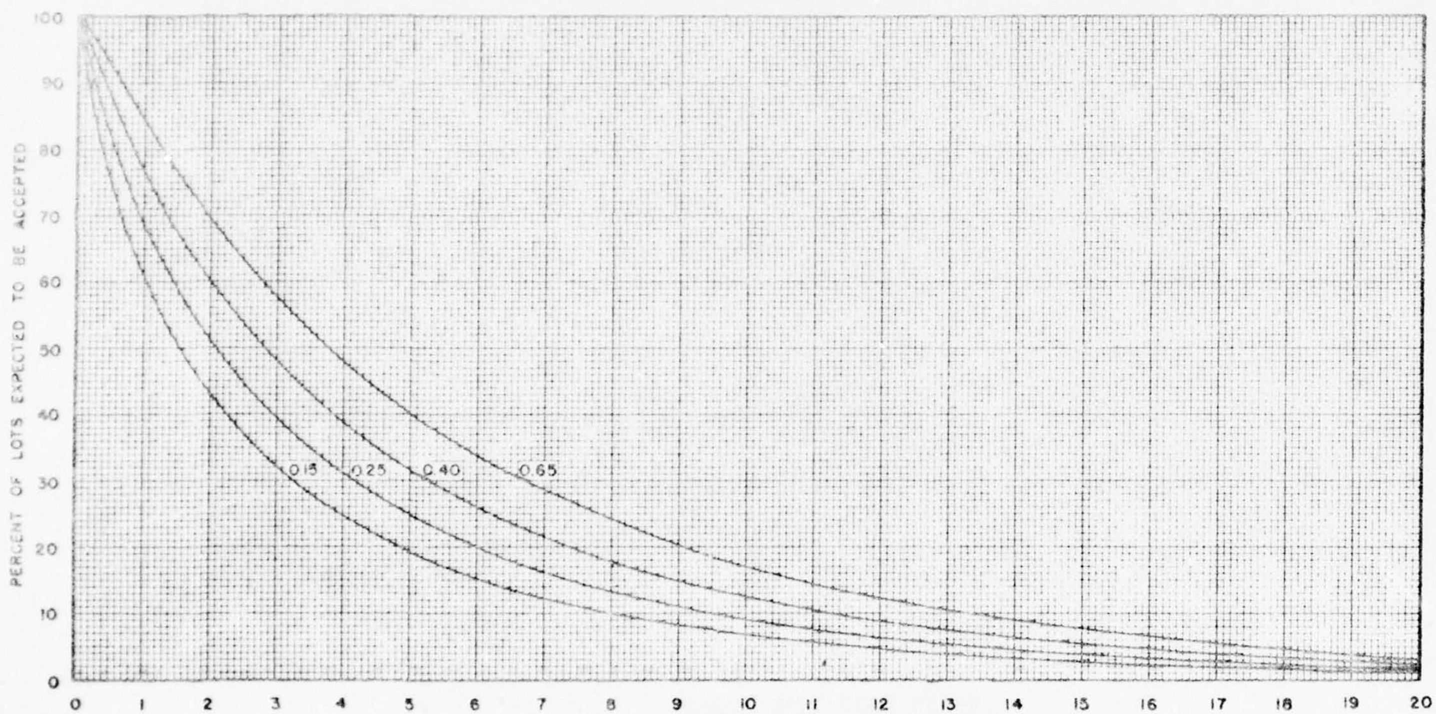
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

F

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

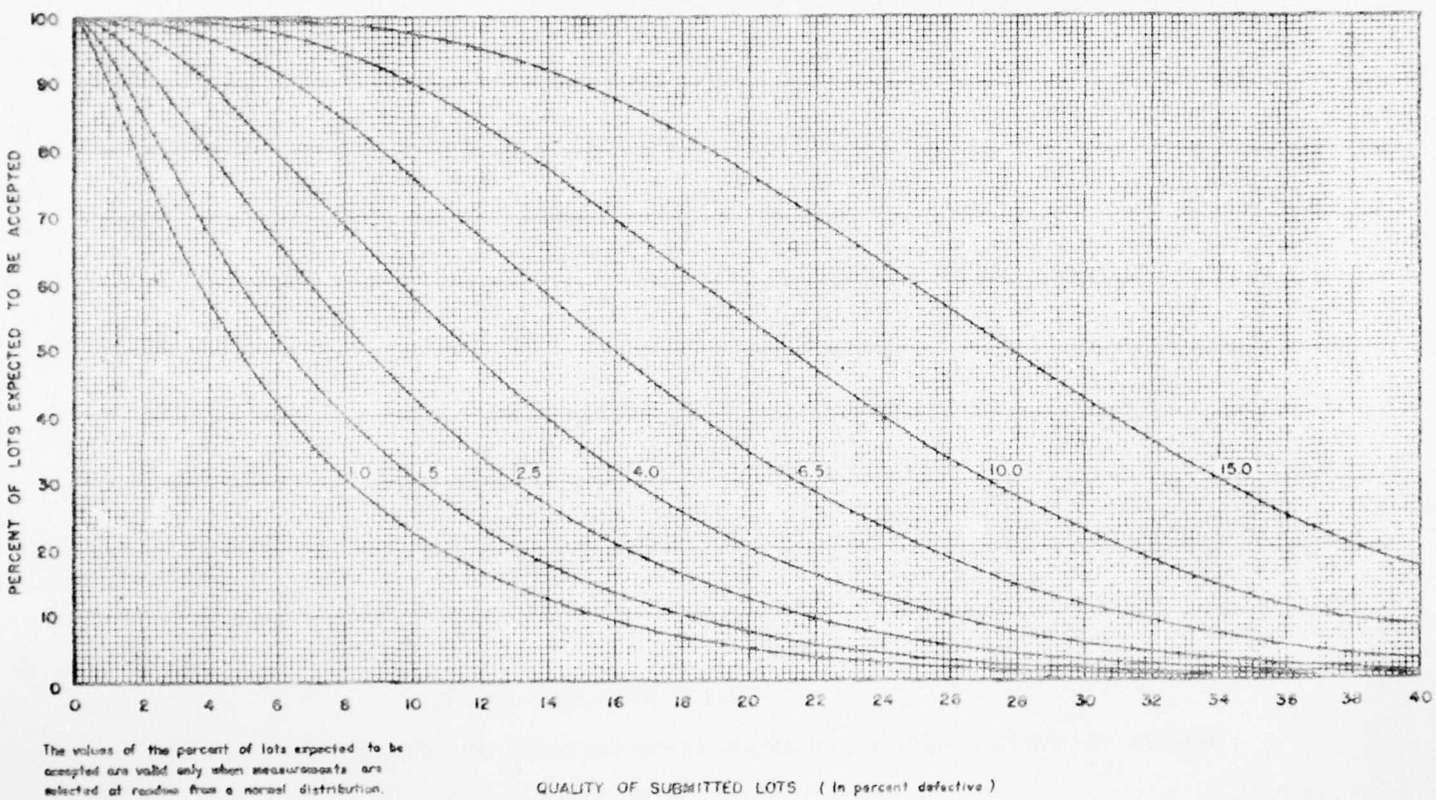
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

F (Continued)

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

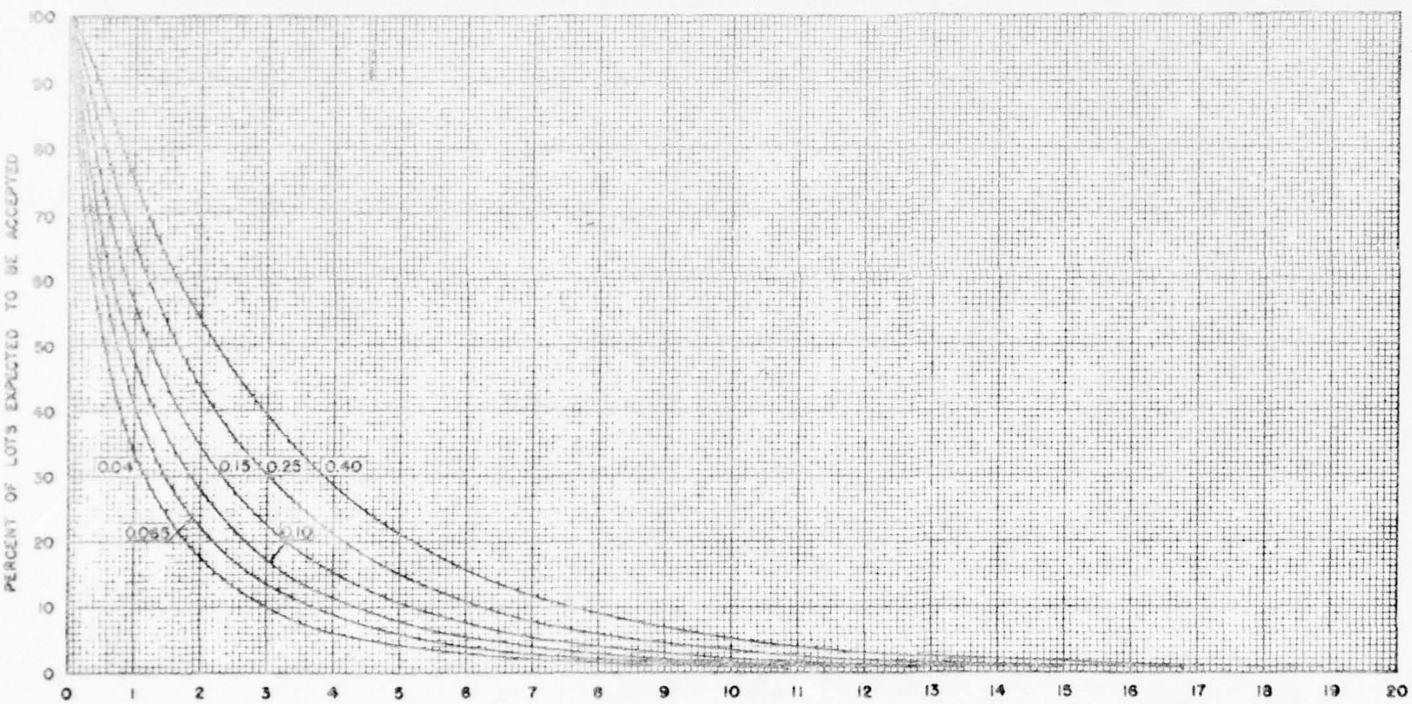
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

G

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

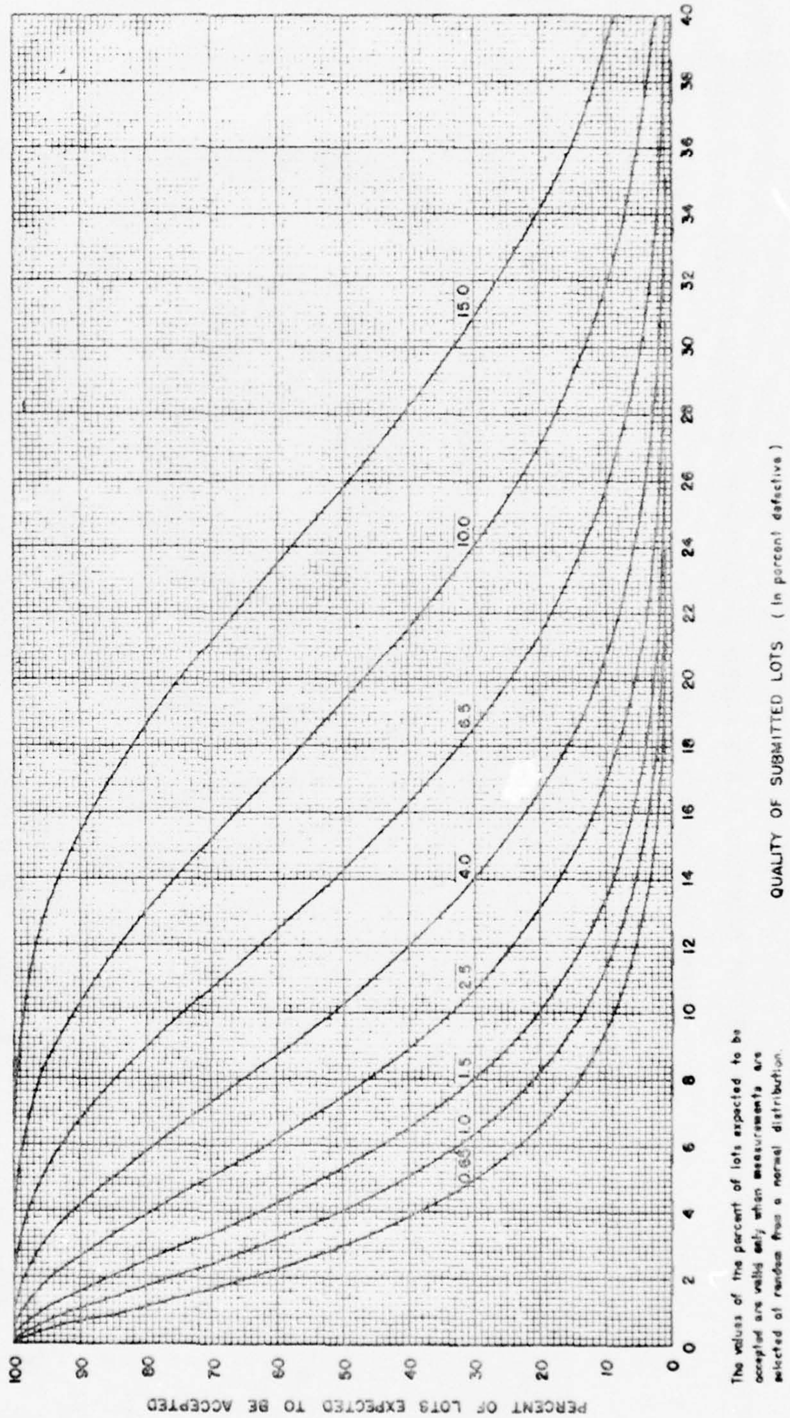
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

G (Continued)

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

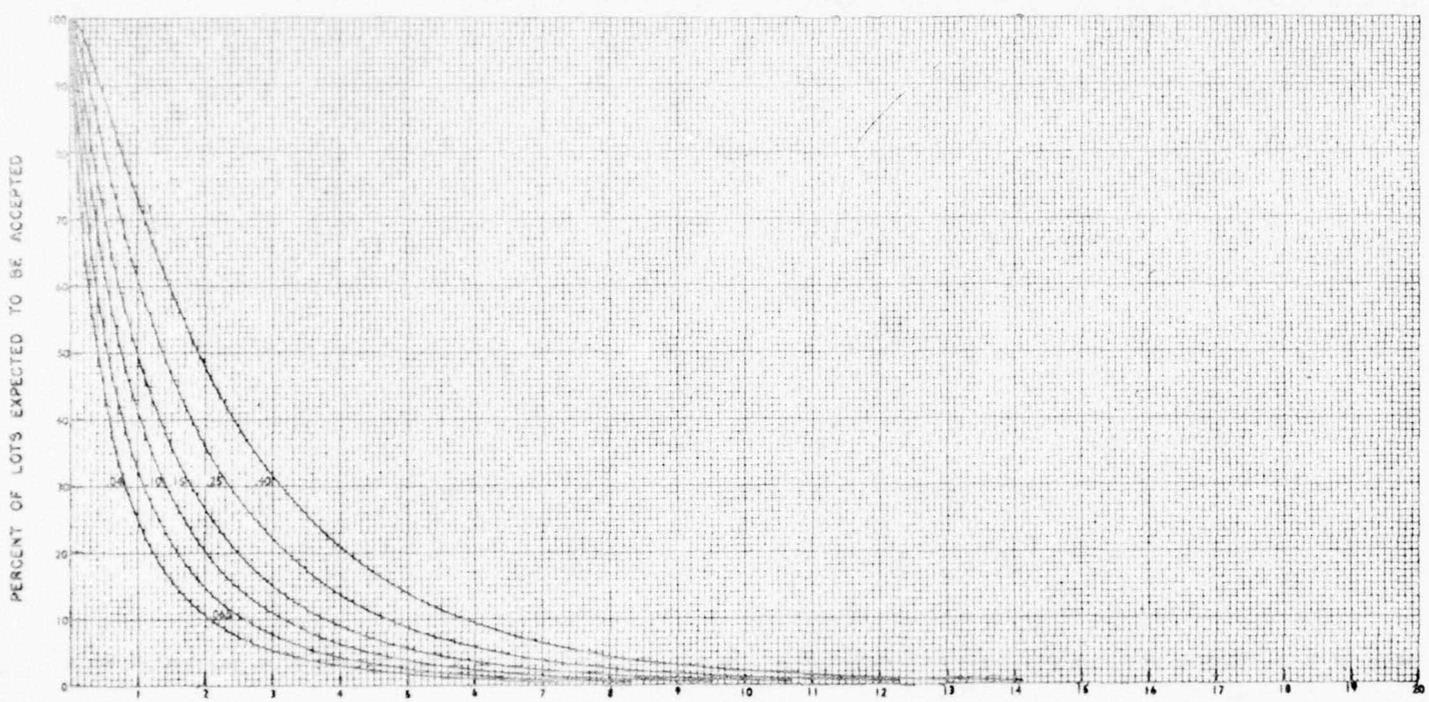
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

H

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

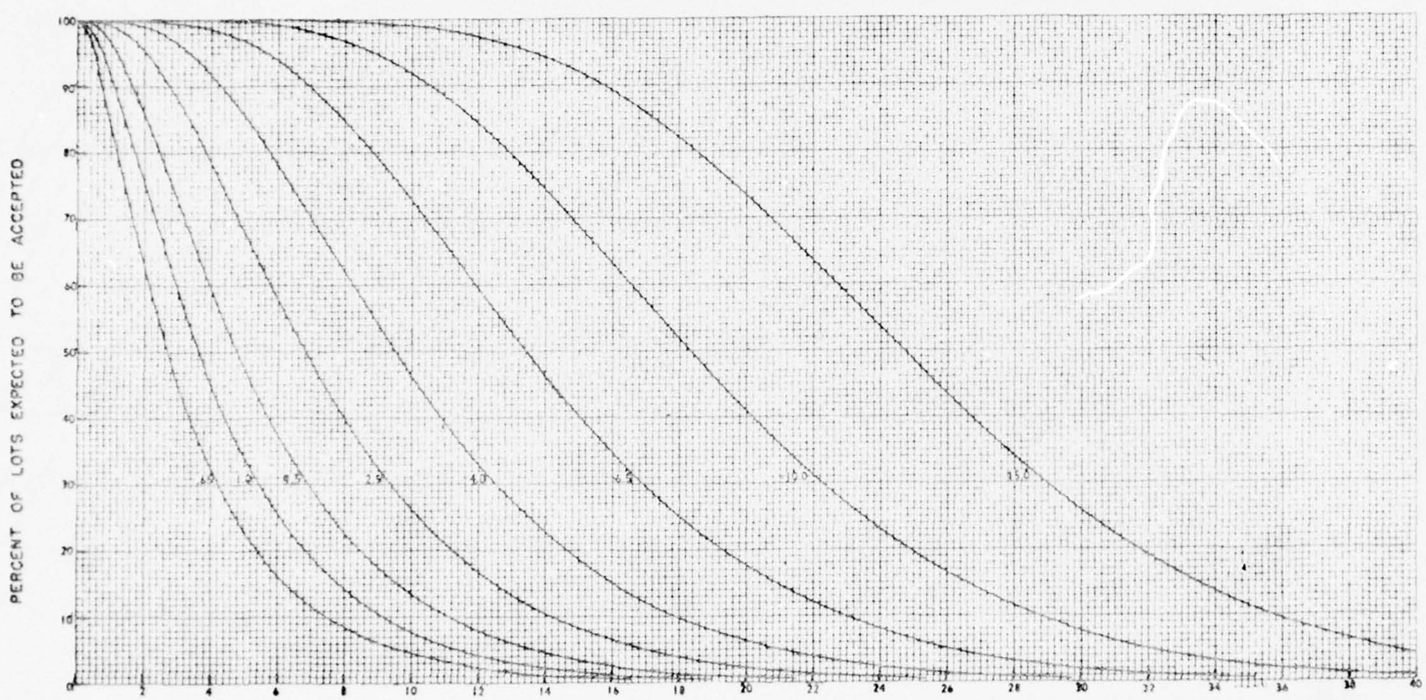
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

H (Continued)

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

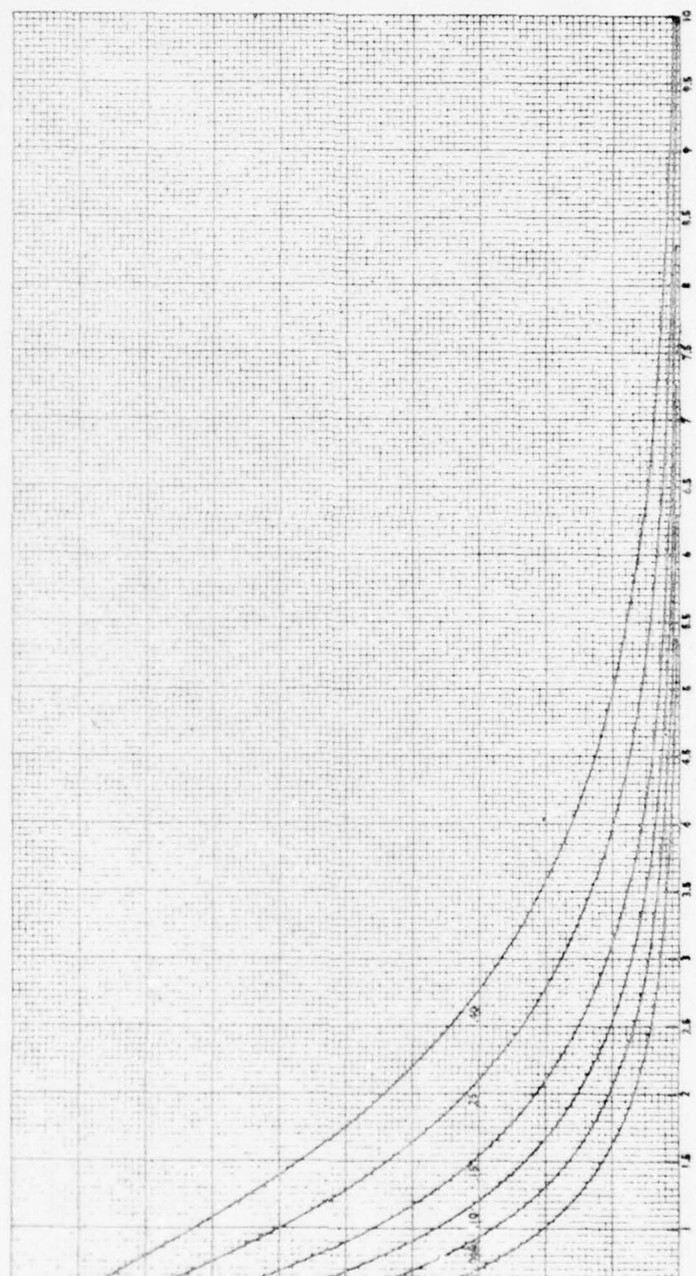
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

I

(Curves for sampling plans based on range method and known variability are essentially equivalent)



PERCENT OF LOTS EXPECTED TO BE ACCEPTED

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

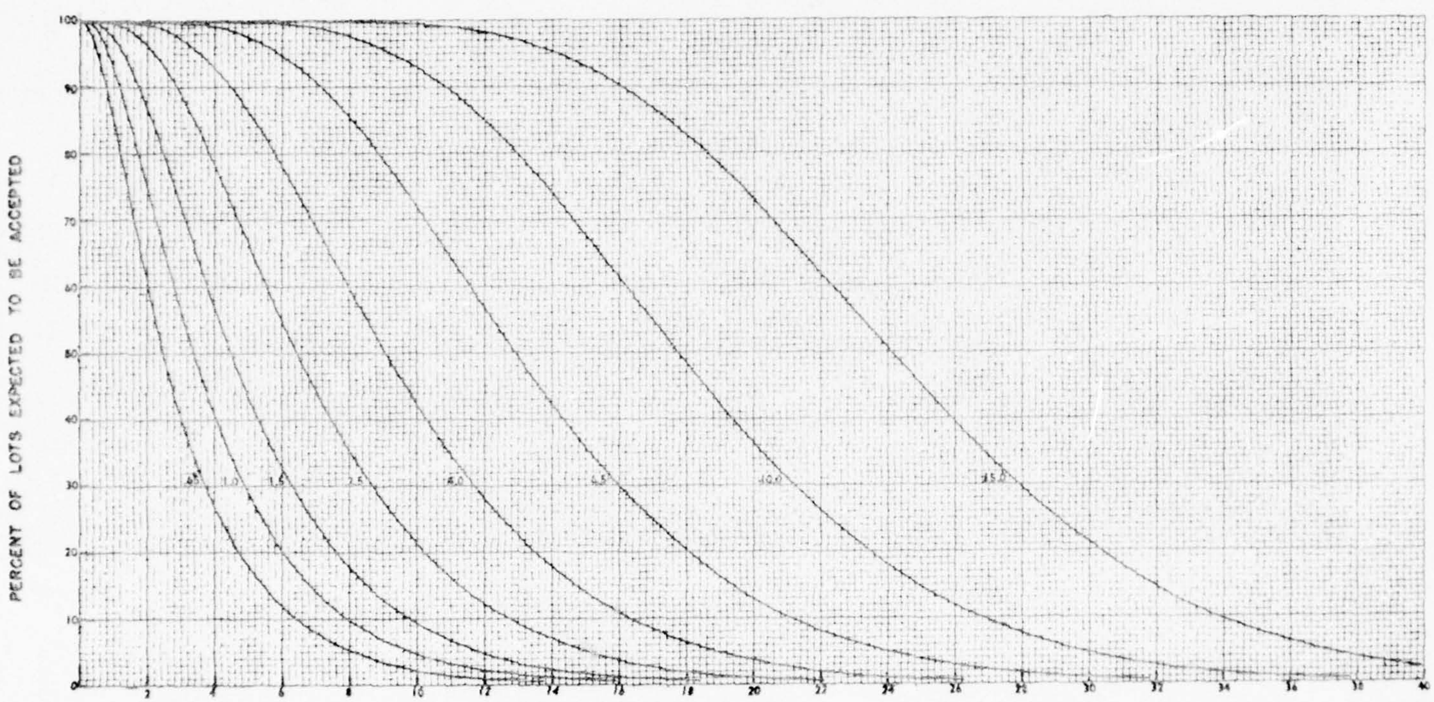
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

I (Continued)

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

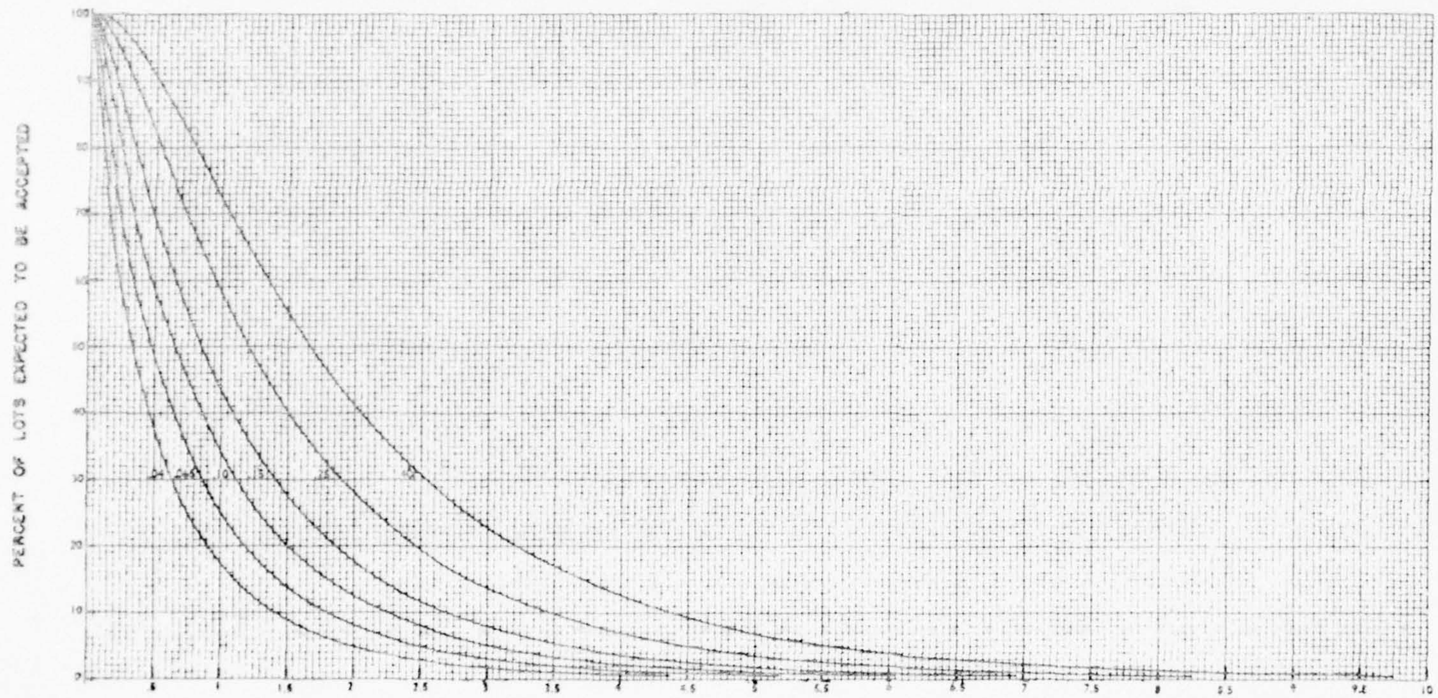
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

J

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

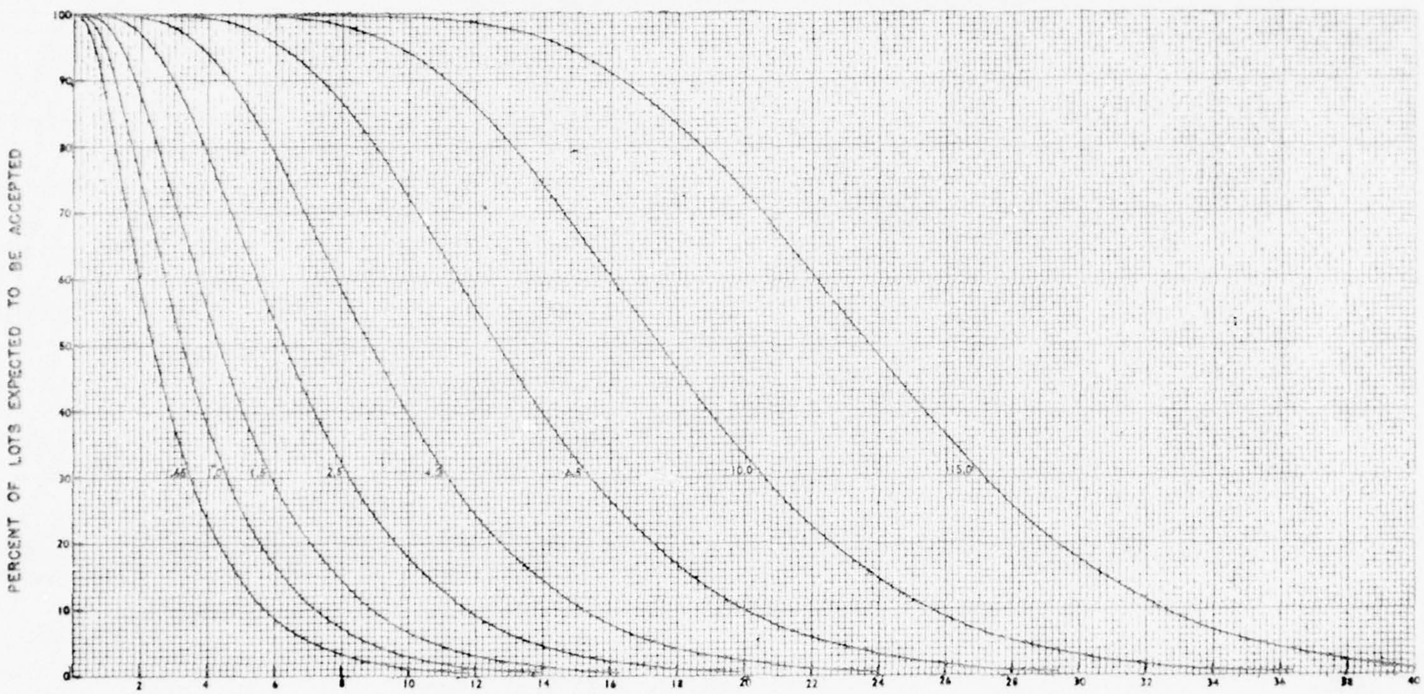
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

J (Continued)

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

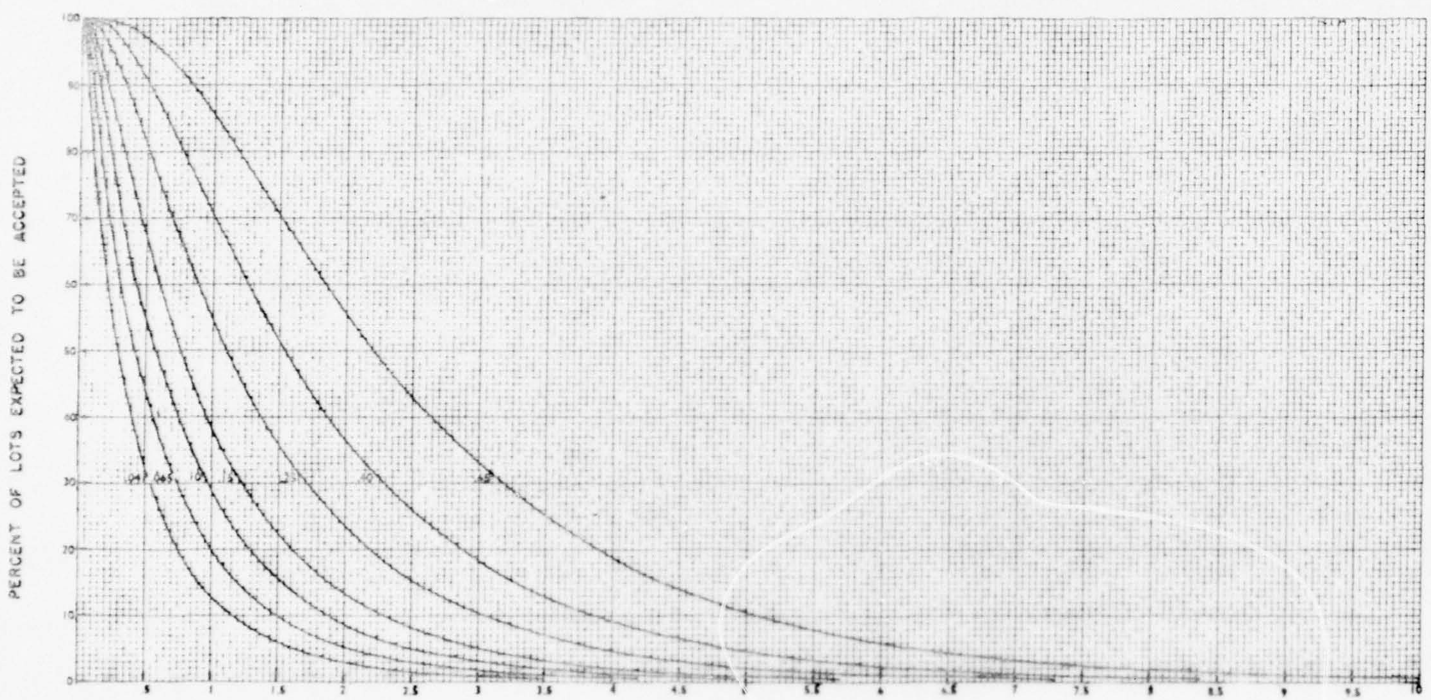
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

K

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

TABLE A-3

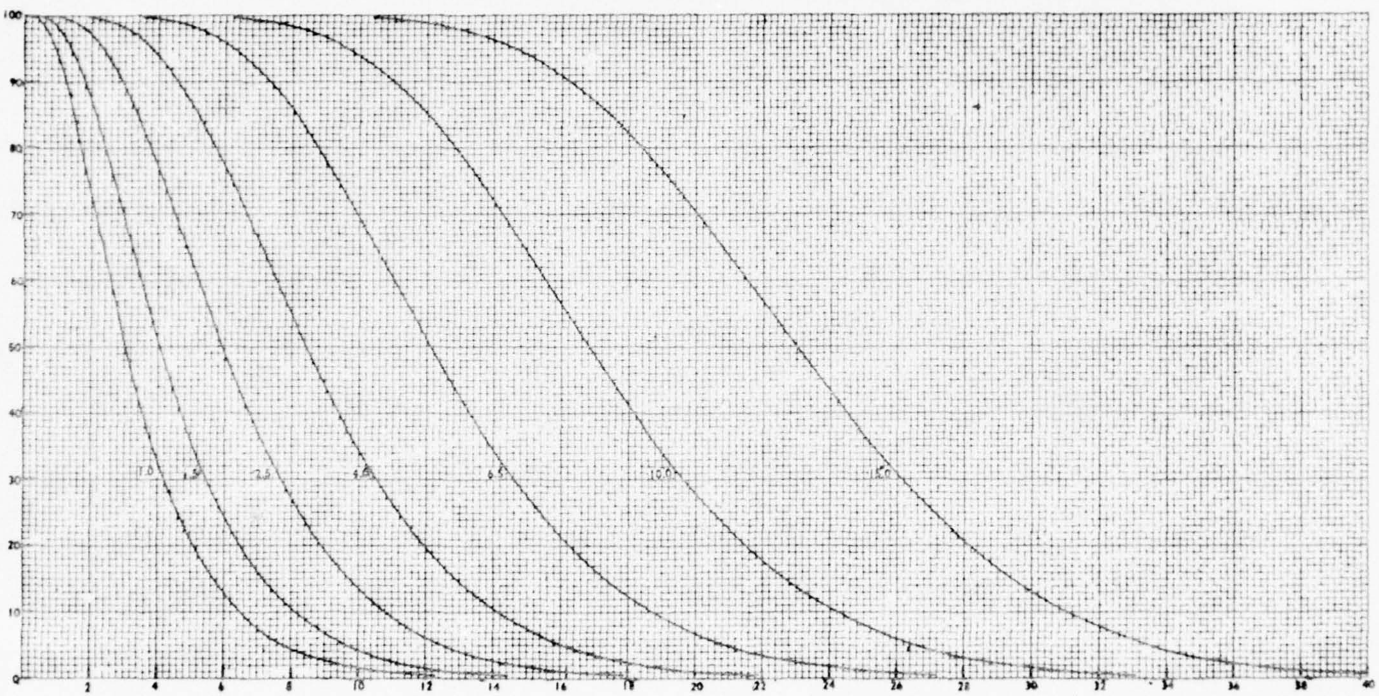
OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

K (Continued)

(Curves for sampling plans based on range method and known variability are essentially equivalent)

PERCENT OF LOTS EXPECTED TO BE ACCEPTED



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

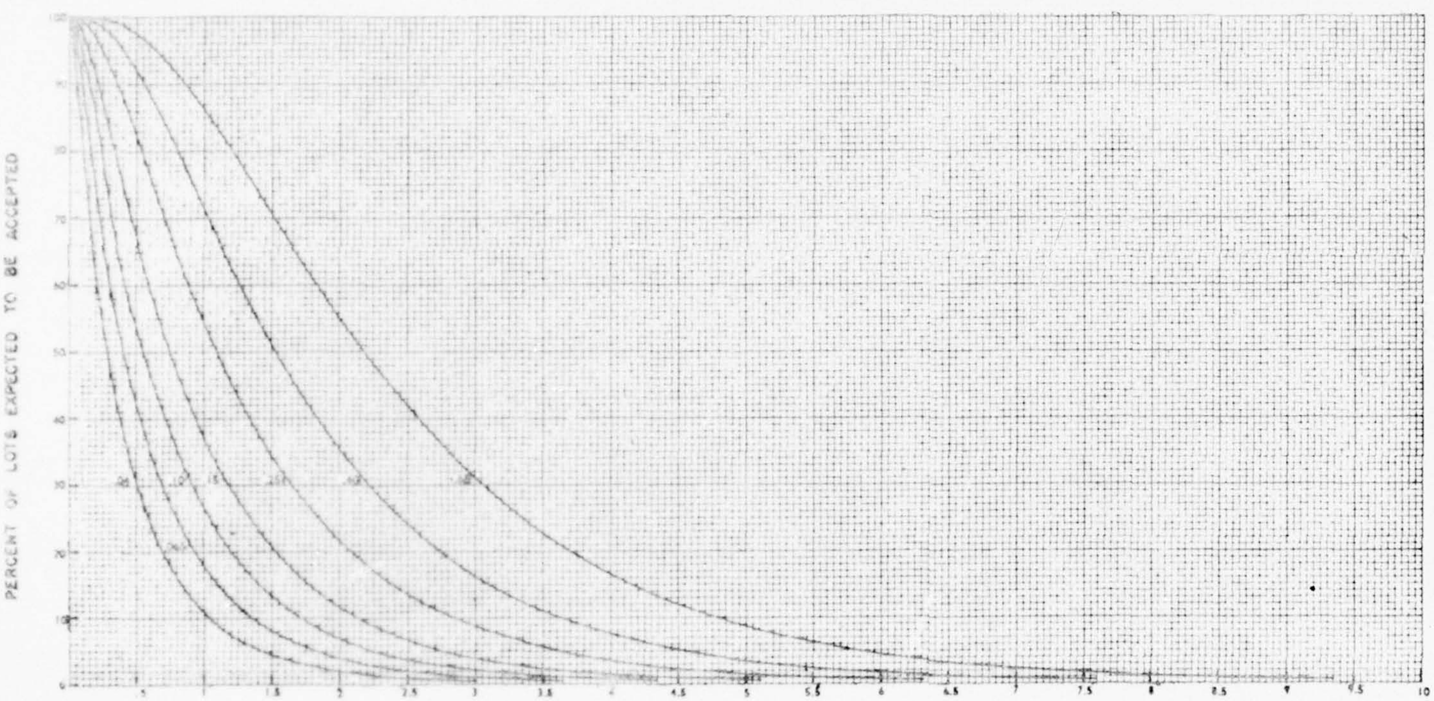
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

L

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

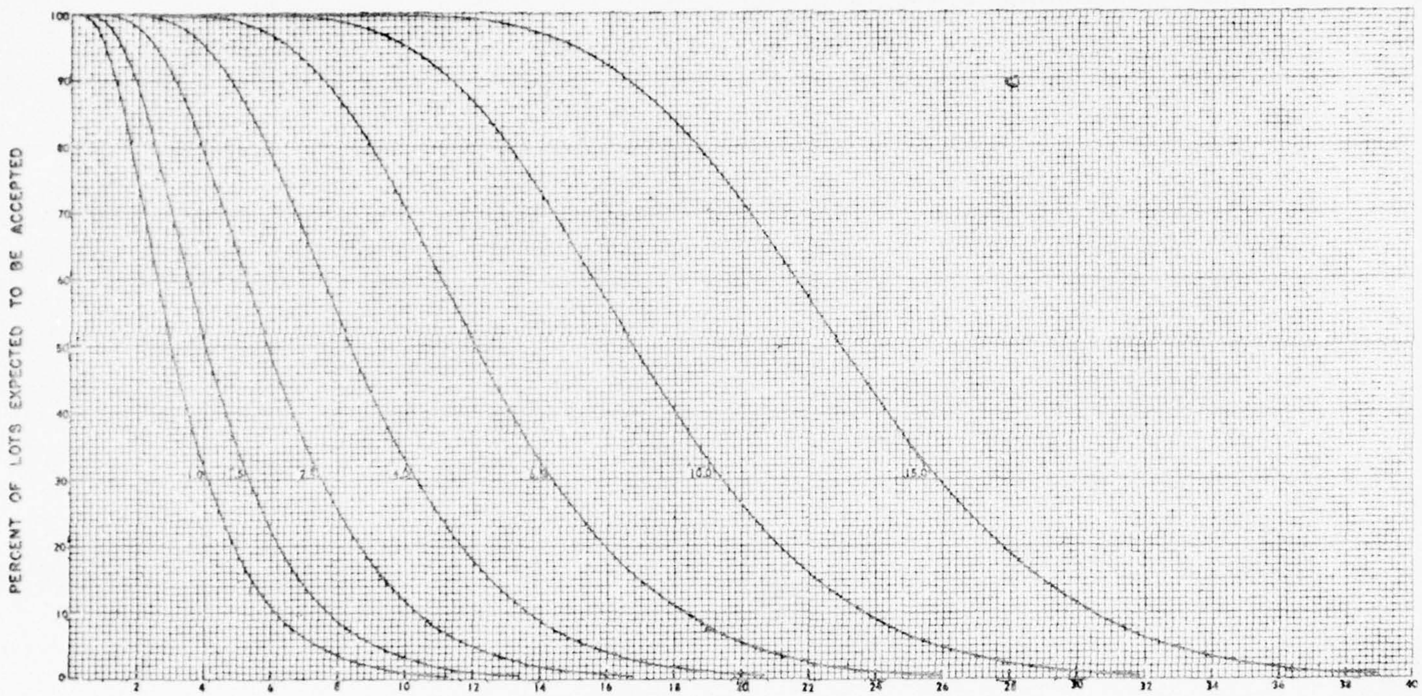
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

L (Continued)

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

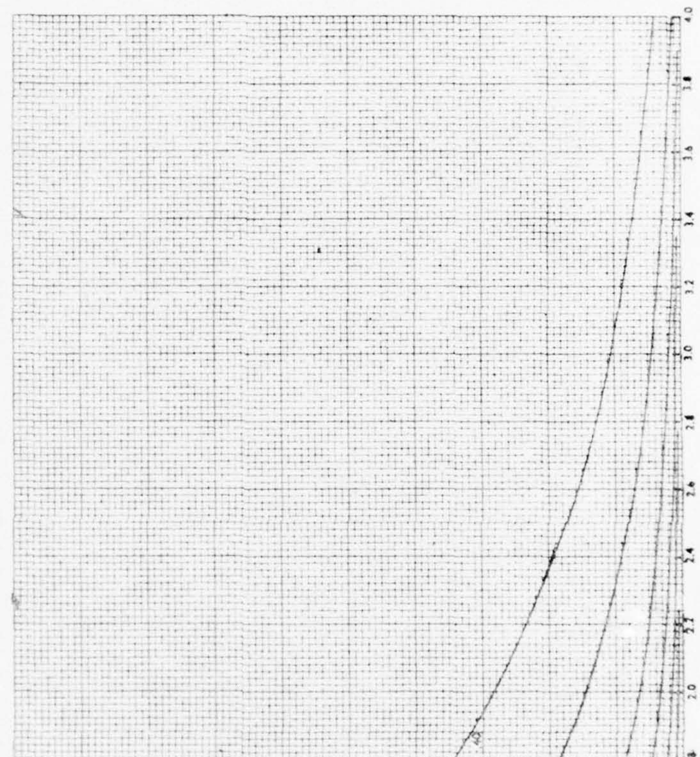
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

M

(Curves for sampling plans based on range method and known variability are essentially equivalent)



QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

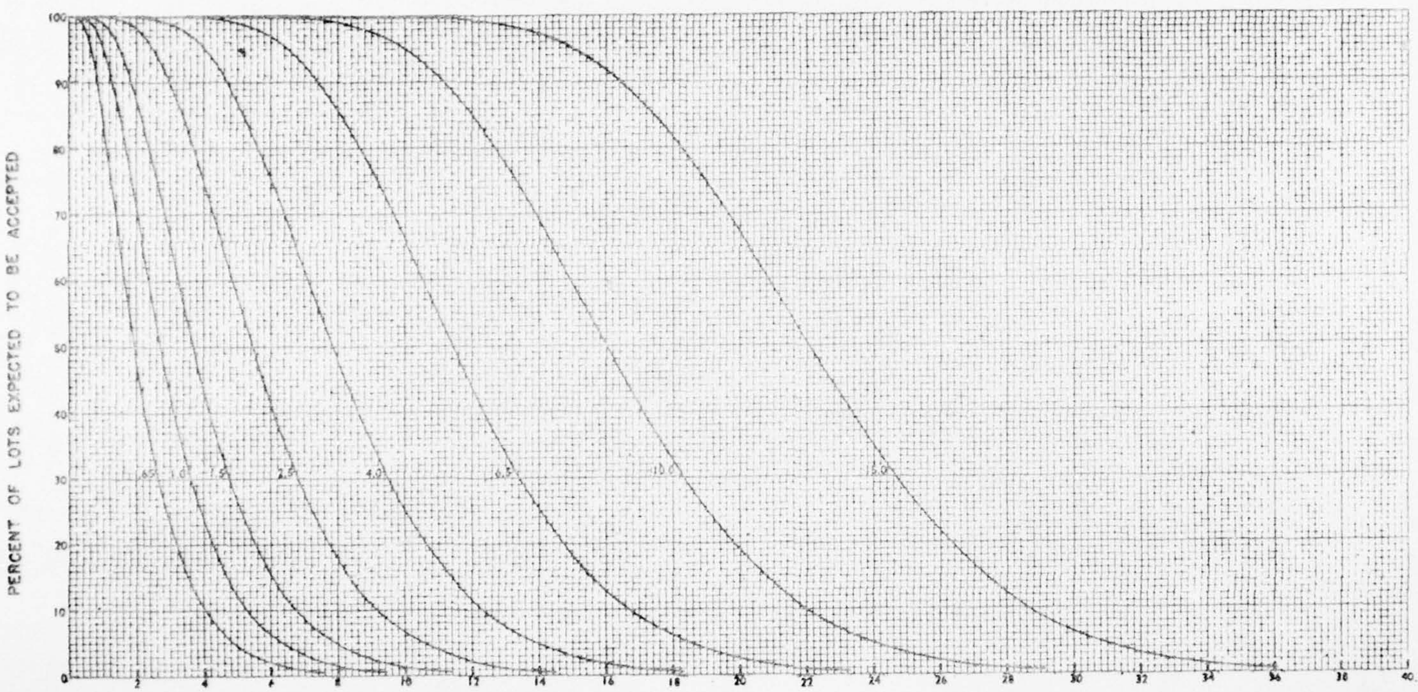
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

M (Continued)

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

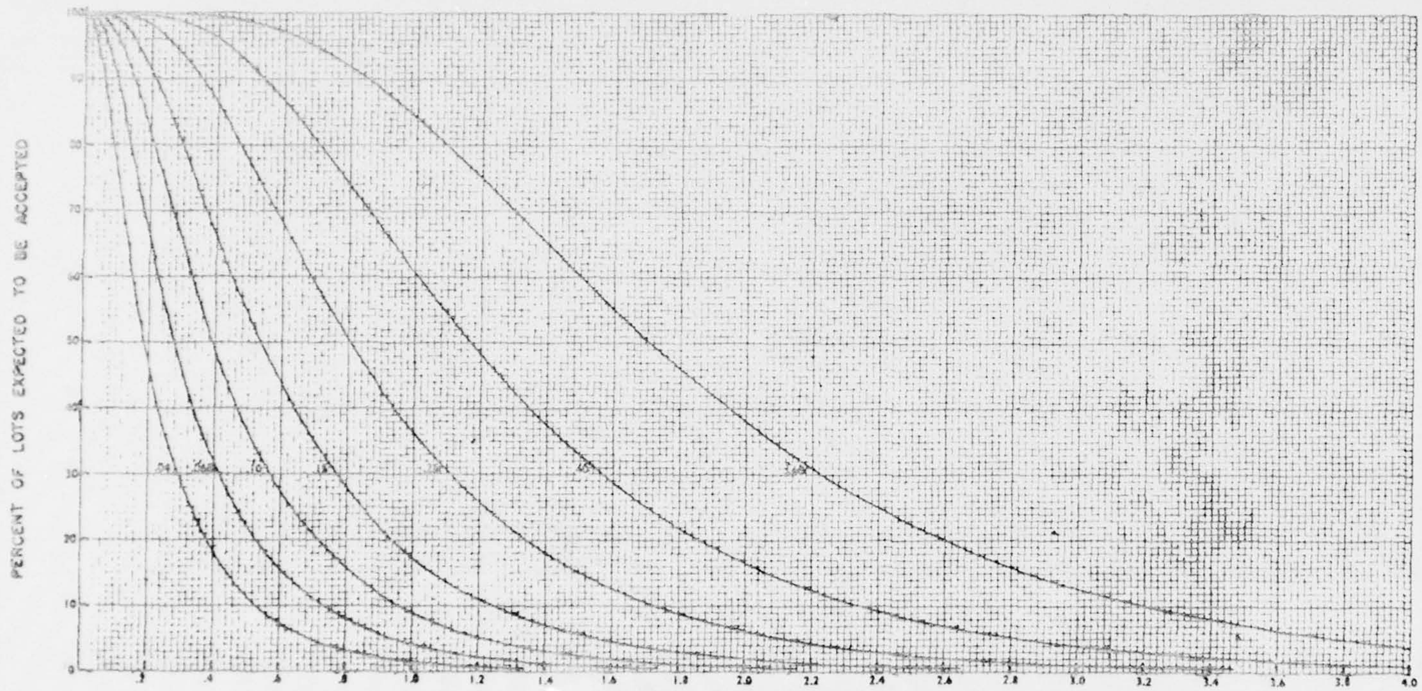
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

N

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

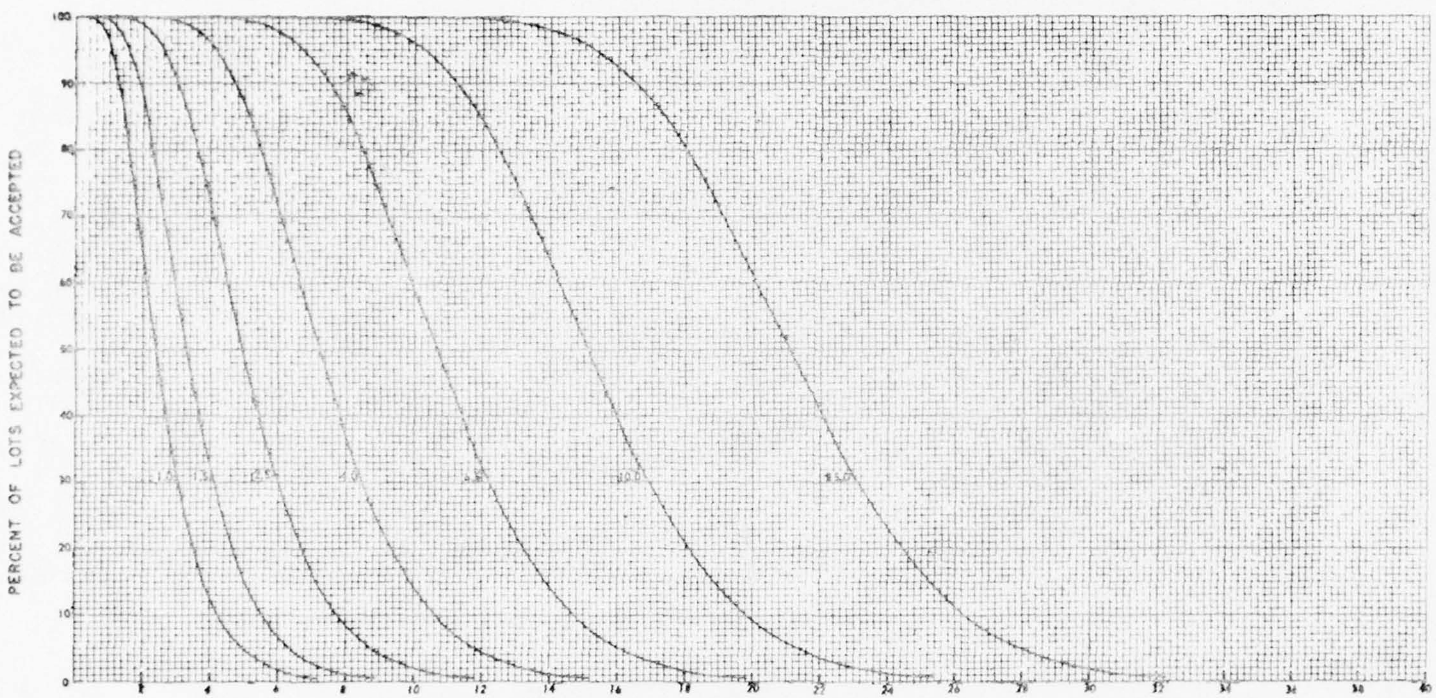
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

N (Continued)

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

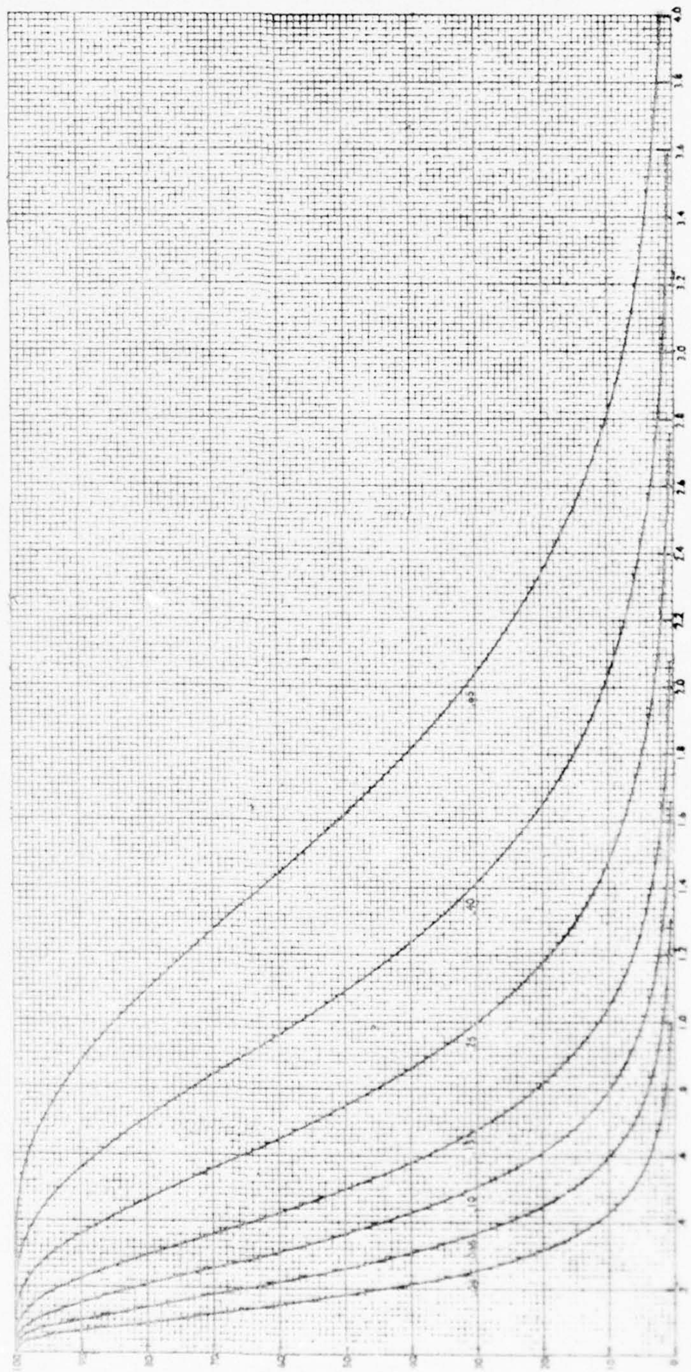
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

O

(Curves for sampling plans based on range method and known variability are essentially equivalent)



Note: Figures on curves are Acceptable Quality Levels for normal inspection.

The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

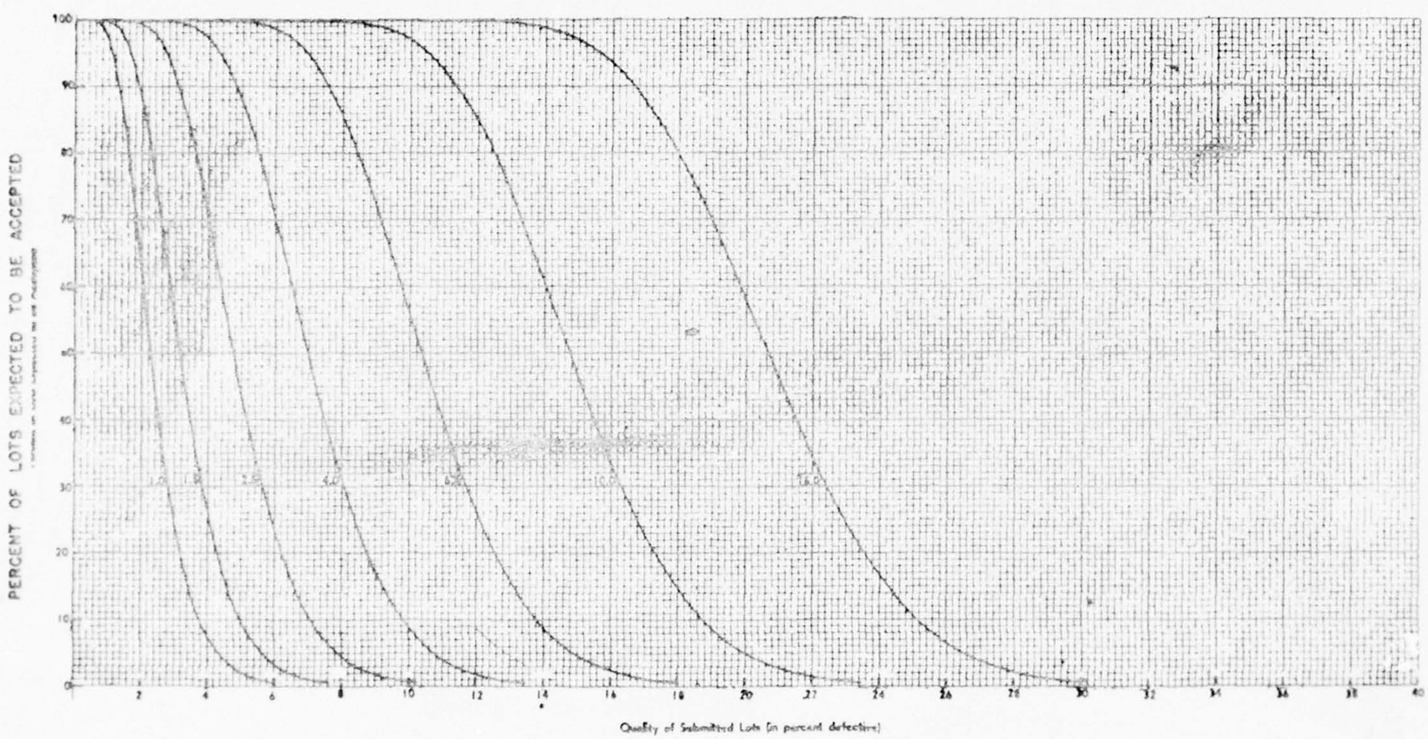
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

O (Continued)

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

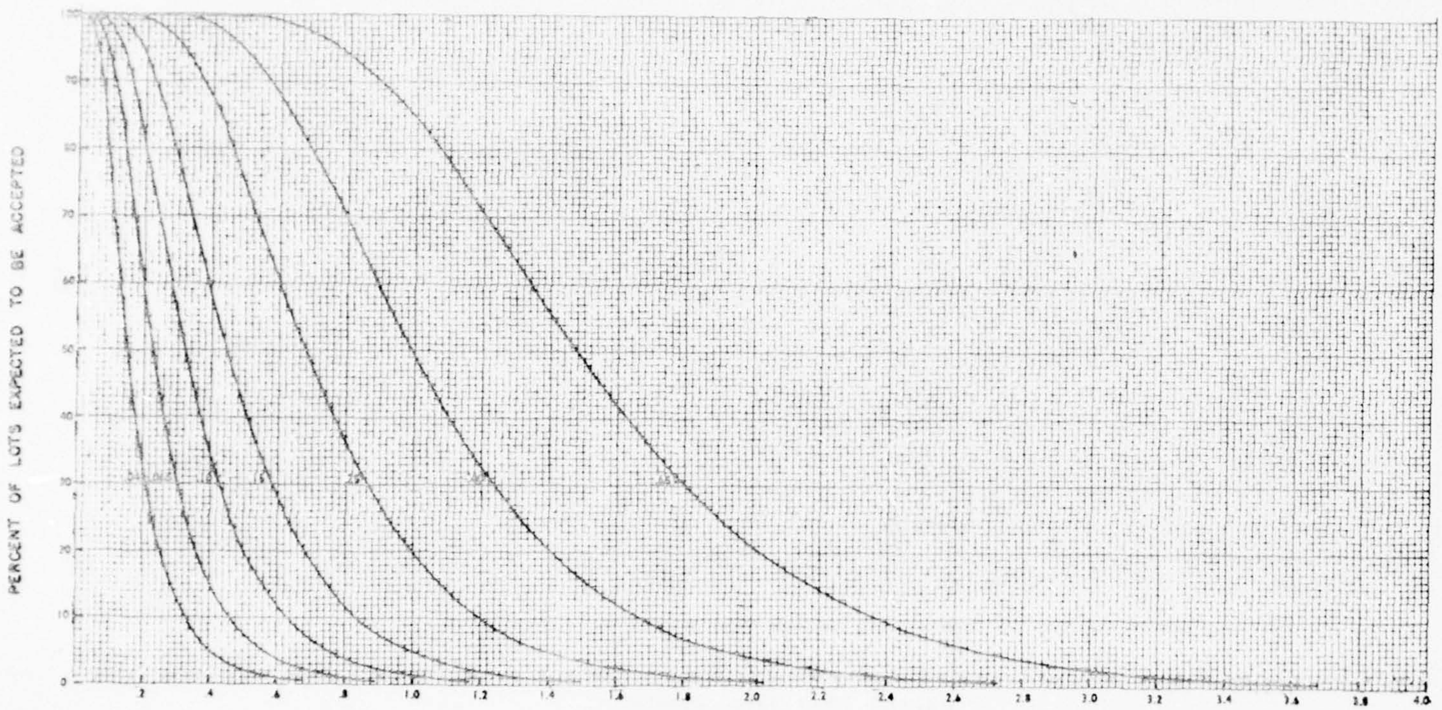
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

P

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

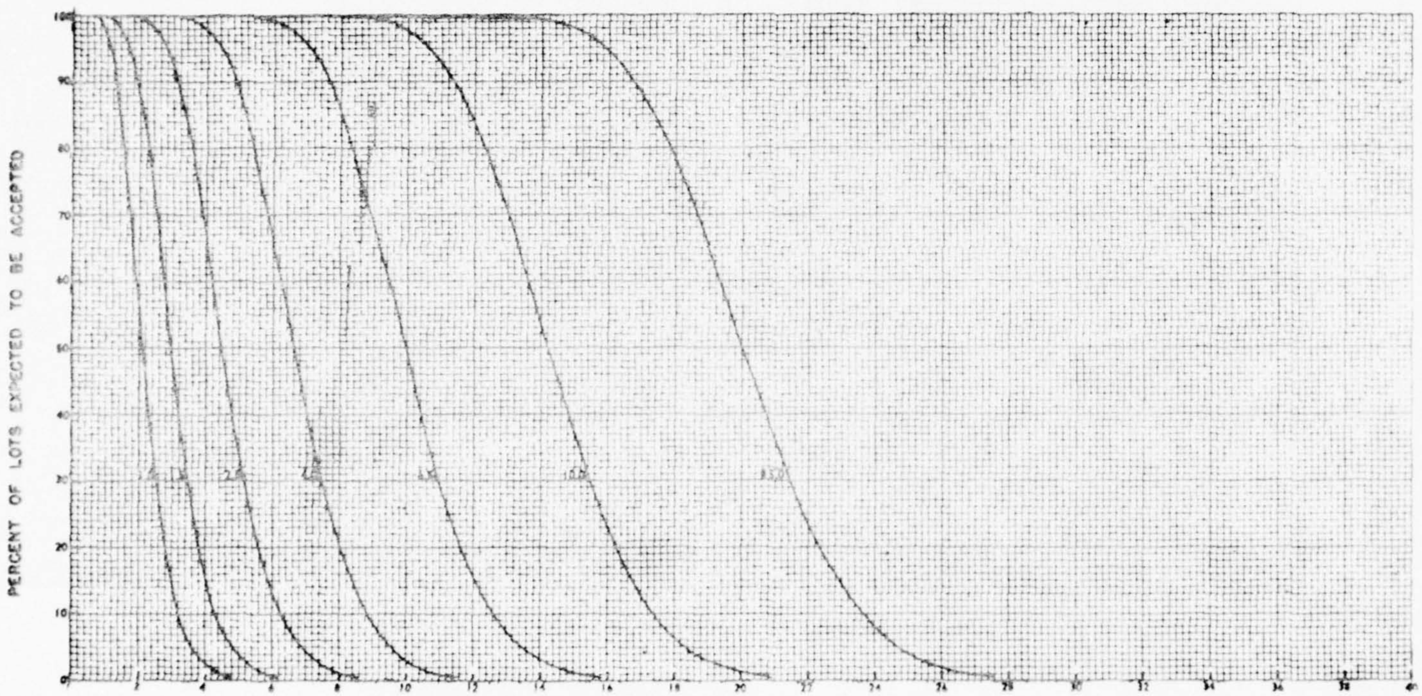
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

P (Continued)

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

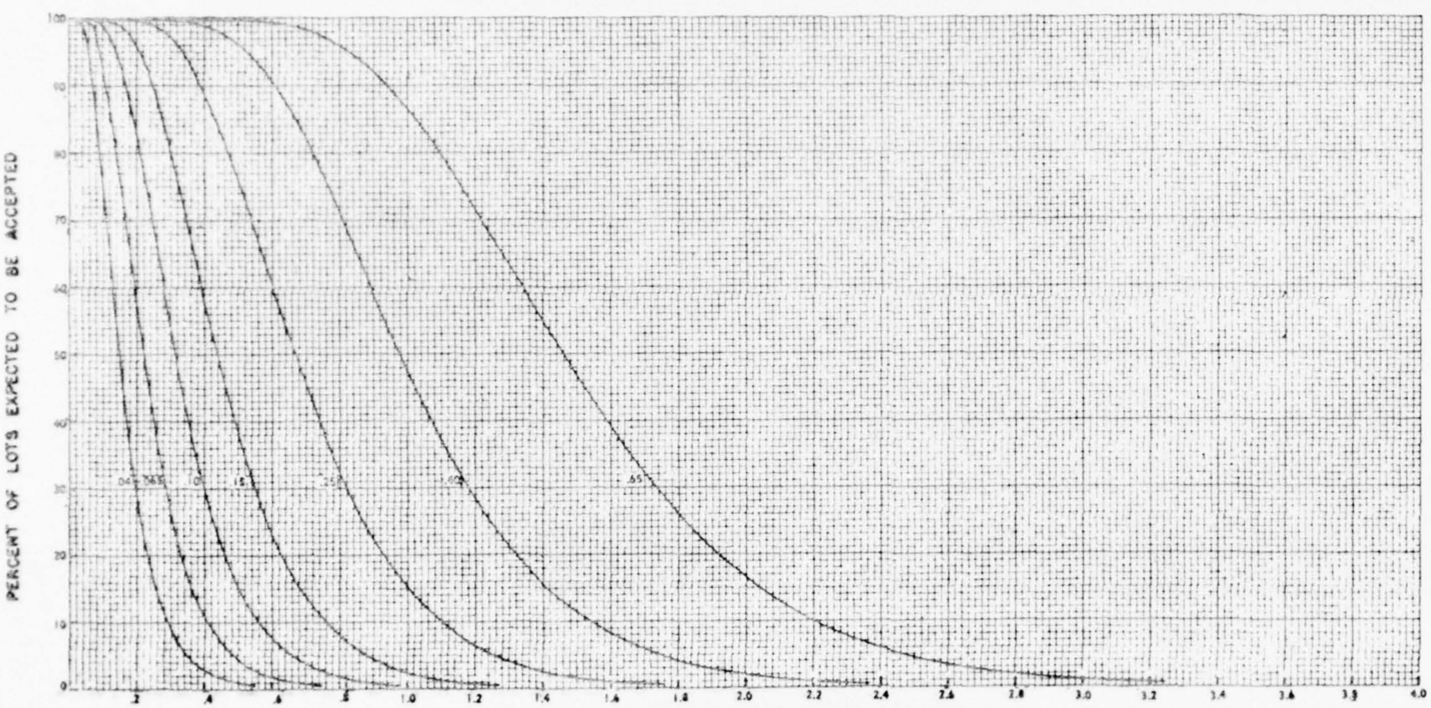
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

Q

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

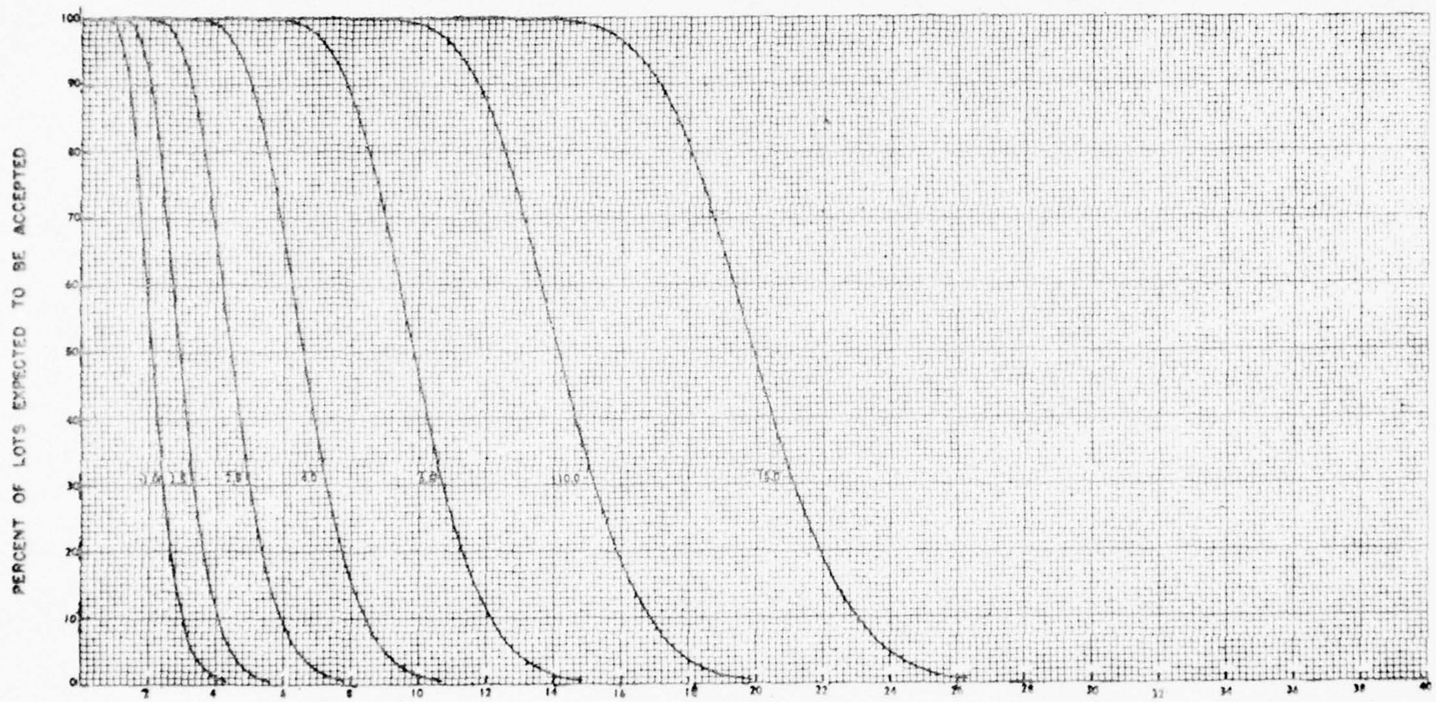
TABLE A-3

OPERATING CHARACTERISTIC CURVES FOR SAMPLING PLANS BASED ON STANDARD DEVIATION METHOD

SAMPLE SIZE CODE LETTER

Q (Continued)

(Curves for sampling plans based on range method and known variability are essentially equivalent)



The values of the percent of lots expected to be accepted are valid only when measurements are selected at random from a normal distribution.

QUALITY OF SUBMITTED LOTS (In percent defective)

Note: Figures on curves are Acceptable Quality Levels for normal inspection.

SECTION B

VARIABILITY UNKNOWN—STANDARD DEVIATION METHOD

Part I

SINGLE SPECIFICATION LIMIT

B1. SAMPLING PLAN FOR SINGLE SPECIFICATION LIMIT

This part of the Standard describes the procedures for use with plans for a single specification limit when variability of the lot with respect to the quality characteristic is unknown and the standard deviation method is used. The acceptability criterion is given in two equivalent forms. These are identified as Form 1 and Form 2.

B1.1 Use of Sampling Plans. To determine whether the lot meets the acceptability criterion with respect to a particular quality characteristic and AQL value, the applicable sampling plan shall be used in accordance with the provisions of Section A, General Description of Sampling Plans, and those in this part of the Standard.

B1.2 Drawing of Samples. All samples shall be drawn in accordance with paragraph A7.2.

B1.3 Determination of Sample Size Code Letter. The sample size code letter shall be selected from Table A-2 in accordance with paragraph A7.1.

B2. SELECTING THE SAMPLING PLAN WHEN FORM 1 IS USED

B2.1 Master Sampling Tables. The master sampling tables for plans based on variability unknown for a single specification limit when using the standard deviation method are Tables B-1 and B-2. Table B-1 is used for normal and tightened inspection and Table B-2 for reduced inspection.

B2.2 Obtaining the Sampling Plan. The sampling plan consists of a sample size and an associated acceptability constant.[1] The sampling plan is obtained from Master Table B-1 or B-2.

B2.2.1 Sample Size. The sample size n is shown in the master table corresponding to each sample size code letter.

B2.2.2 Acceptability Constant. The acceptability constant k, corresponding to the sample size mentioned in paragraph B2.2.1, is indicated in the column of the master table corresponding to the applicable AQL value. Table B-1 is entered from the top for normal inspection and from the bottom for tightened inspection. Sampling plans for reduced inspection are provided in Table B-2.

B3. LOT-BY-LOT ACCEPTABILITY PROCEDURES WHEN FORM 1 IS USED[2]

B3.1 Acceptability Criterion. The degree of conformance of a quality characteristic with respect to a single specification limit shall be judged by the quantity $(U-\bar{X})/s$ or $(\bar{X}-L)/s$.

B3.2 Computation. The following quantity shall be computed: $(U-\bar{X})/s$ or $(\bar{X}-L)/s$, depending on whether the specification limit is an upper or lower limit, where

U is the upper specification limit,
L is the lower specification limit,
$\bar{X}$ is the sample mean, and
s is the estimate of lot standard deviation.

B3.3 Acceptability Criterion. Compare the quantity $(U-\bar{X})/s$ or $(\bar{X}-L)/s$ with the acceptability constant k. If $(U-\bar{X})/s$ or $(\bar{X}-L)/s$ is equal to or greater than k, the lot meets the acceptability criterion; if $(U-\bar{X})/s$ or $(\bar{X}-L)/s$ is less than k or negative, then the lot does not meet the acceptability criterion.

B4. SUMMARY FOR OPERATION OF SAMPLING PLAN WHEN FORM 1 IS USED

The following steps summarize the procedures to be followed:

(1) Determine the sample size code letter from Table A-2 by using the lot size and inspection level.

[1] See Appendix B for definitions of all symbols used in the sampling plans based on variability unknown-standard deviation method.
[2] See Example B-1 for a complete example of this procedure.

(2) Obtain plan from Master Table B-1 or B-2 by selecting the sample size n and the acceptability constant k.

(3) Select at random the sample of n units from the lot; inspect and record the measurement of the quality characteristic for each unit of the sample.

(4) Compute the sample mean $\overline{X}$ and estimate of lot standard deviation s, and also compute the quantity $(U-\overline{X})/s$ for an upper specification limit U or the quantity $(\overline{X}-L)/s$ for a lower specification limit L.

(5) If the quantity $(U-\overline{X})/s$ or $(\overline{X}-L)/s$ is equal to or greater than k, the lot meets the acceptability criterion; if $(U-\overline{X})/s$ or $(\overline{X}-L)/s$ is less than k or negative, then the lot does not meet the acceptability criterion.

B5. SELECTING THE SAMPLING PLAN WHEN FORM 2 IS USED

B5.1 Master Sampling Tables. The master sampling tables for plans based on variability unknown for a single specification limit when using the standard deviation method are Tables B-3 and B-4 of Part II. Table B-3 is used for normal and tightened inspection and Table B-4 for reduced inspection.

B5.2 Obtaining the Sampling Plan. The sampling plan consists of a sample size and an associated maximum allowable percent defective. The sampling plan is obtained from Master Table B-3 or B-4.

B5.2.1 Sample Size. The sample size n is shown in the master table corresponding to each sample size code letter.

B5.2.2 Maximum Allowable Percent Defective. The maximum allowable percent defective M for sample estimates corresponding to the sample size mentioned in paragraph B5.2.1 is indicated in the column of the master table corresponding to the applicable AQL value. Table B-3 is entered from the top for normal inspection and from the bottom for tightened inspection. Sampling plans for reduced inspection are provided in Table B-4.

B6. LOT-BY-LOT ACCEPTABILITY PROCEDURES WHEN FORM 2 IS USED[3]

B6.1 Acceptability Criterion. The degree of conformance of a quality characteristic with respect to a single specification limit shall be judged by the percent of nonconforming product outside the upper or lower specification limit. The percentage of nonconforming product is estimated by entering Table B-5 with the quality index and the sample size.

B6.2 Computation of Quality Index. The quality index $Q_U = (U-\overline{X})/s$ shall be computed if the specification limit is an upper limit U, or $Q_L = (\overline{X}-L)/s$ if it is a lower limit L. The quantities, $\overline{X}$ and s, are the sample mean and estimate of lot standard deviation, respectively.

B6.3 Estimate of Percent Defective in Lot. The quality of a lot shall be expressed by p_U, the estimated percent defective in the lot above the upper specification limit, or by p_L, the estimated percent defective below the lower specification limit. The estimated percent defective p_U or p_L is obtained by entering Table B-5 with Q_U or Q_L and the appropriate sample size.

B6.4 Acceptability Criterion. Compare the estimated lot percent defective p_U or p_L with the maximum allowable percent defective M. If p_U or p_L is equal to or less than M, the lot meets the acceptability criterion; if p_U or p_L is greater than M or if Q_U or Q_L is negative, then the lot does not meet the acceptability criterion.

B7. SUMMARY FOR OPERATION OF SAMPLING PLAN WHEN FORM 2 IS USED

The following steps summarize the procedures to be followed:

(1) Determine the sample size code letter from Table A-2 by using the lot size and the inspection level.

(2) Obtain plan from Master Table B-3 or B-4 by selecting the sample size n and the maximum allowable percent defective M.

(3) Select at random the sample of n units from the lot; inspect and record the measurement of the quality characteristic on each unit of the sample.

(4) Compute the sample mean $\overline{X}$ and the estimate of lot standard deviation s.

(5) Compute the quality index $Q_U = (U-\overline{X})/s$ if an upper specification limit U is specified, or $Q_L = (\overline{X}-L)/s$ if a lower specification limit L is specified.

(6) Determine the estimated lot percent defective p_U or p_L from Table B-5.

[3] See Example B-2 for a complete example of this procedure.

(7) If the estimated lot percent defective p_U or p_L is equal to or less than the maximum allowable percent defective M, the lot meets the acceptability criterion; if p_U or p_L is greater than M or if Q_U or Q_L is negative, then the lot does not meet the acceptability criterion.

EXAMPLE B-1

Example of Calculations

Single Specification Limit—Form 1

Variability Unknown - Standard Deviation Method

Example The maximum temperature of operation for a certain device is specified as 209° F. A lot of 40 items is submitted for inspection. Inspection Level IV, normal inspection, with AQL = 1% is to be used. From Tables A-2 and B-1 it is seen that a sample of size 5 is required. Suppose the measurements obtained are as follows: 197°, 188°, 184°, 205°, and 201°; and compliance with the acceptability criterion is to be determined.

Line	Information Needed	Value Obtained	Explanation
1	Sample Size: n	5	
2	Sum of Measurements: ΣX	975	
3	Sum of Squared Measurements: ΣX^2	190,435	
4	Correction Factor (CF): $(\Sigma X)^2/n$	190,125	$(975)^2/5$
5	Corrected Sum of Squares (SS): $\Sigma X^2 - CF$	310	190,435 - 190,125
6	Variance (V): SS/(n-1)	77.5	310/4
7	Estimate of Lot Standard Deviation s: $\sqrt{V}$	8.81	$\sqrt{77.5}$
8	Sample Mean $\bar{X}$: $\Sigma X/n$	195	975/5
9	Specification Limit (Upper): U	209	
10	The quantity: $(U-\bar{X})/s$	1.59	(209 - 195)/8.81
11	Acceptability Constant: k	1.53	See Table B-1
12	Acceptability Criterion: Compare $(U-\bar{X})/s$ with k	1.59 > 1.53	See Para. B3.3

The lot meets the acceptability criterion, since $(U-\bar{X})/s$ is greater than k.

NOTE: If a single lower specification limit L is given, then compute the quantity $(\bar{X}-L)/s$ in line 10 and compare it with k; the lot meets the acceptability criterion, if $(\bar{X}-L)/s$ is equal to or greater than k.

EXAMPLE B-2

Example of Calculations

Single Specification Limit—Form 2

Variability Unknown - Standard Deviation Method

Example: The maximum temperature of operation for a certain device is specified as 209° F. A lot of 40 items is submitted for inspection. Inspection Level IV, normal inspection, with AQL = 1% is to be used. From Tables A-2 and B-1 it is seen that a sample of size 5 is required. Suppose the measurements obtained are as follows: 197°, 188°, 184°, 205°, and 201°; and compliance with the acceptability criterion is to be determined.

Line	Information Needed	Value Obtained	Explanation
1	Sample Size: n	5	
2	Sum of Measurements: ΣX	975	
3	Sum of Squared Measurements: ΣX^2	190,435	
4	Correction Factor (CF): $(\Sigma X)^2/n$	190,125	$(975)^2/5$
5	Corrected Sum of Squares (SS): ΣX^2-CF	310	190,435 - 190,125
6	Variance (V): SS/(n-1)	77.5	310/4
7	Estimate of Lot Standard Deviation s: $\sqrt{V}$	8.81	$\sqrt{77.5}$
8	Sample Mean $\bar{X}$: $\Sigma X/n$	195	975/5
9	Specification Limit (Upper): U	209	
10	Quality Index: $Q_U = (U-\bar{X})/s$	1.59	(209-195)/8.81
11	Est. of Lot Percent Def.: p_U	2.19%	See Table B-5
12	Max. Allowable Percent Def.: M	3.32%	See Table B-3
13	Acceptability Criterion: Compare p_U with M	2.19% < 3.32%	See Para. B6.4

The lot meets the acceptability criterion, since p_U is less than M.

NOTE: If a single lower specification limit L is given, then compute the quality index $Q_L = (\bar{X}-L)/s$ in line 10 and obtain the estimate of lot percent defective p_L. Compare p_L with M; the lot meets the acceptability criterion, if p_L is equal to or less than M.

TABLE B-1

Standard Deviation Method

Master Table For Normal and Tightened Inspection for Plans Based on Variability Unknown
(Single Specification Limit—Form 1)

Sample size code letter	Sample size	Acceptable Quality Levels (normal inspection)													
		.04	.065	.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00	15.00
		k	k	k	k	k	k	k	k	k	k	k	k	k	k
B	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	1.12	.958	.765	.566	.341
C	4	↓	↓	↓	↓	↓	↓	↓	1.45	1.34	1.17	1.01	.814	.617	.393
D	5	↓	↓	↓	↓	↓	↓	1.65	1.53	1.40	1.24	1.07	.874	.675	.455
E	7	↓	↓	↓	↓	2.00	1.88	1.75	1.62	1.50	1.33	1.15	.955	.755	.536
F	10	↓	↓	↓	2.24	2.11	1.98	1.84	1.72	1.58	1.41	1.23	1.03	.828	.611
G	15	2.64	2.53	2.42	2.32	2.20	2.06	1.91	1.79	1.65	1.47	1.30	1.09	.886	.664
H	20	2.69	2.58	2.47	2.36	2.24	2.11	1.96	1.82	1.69	1.51	1.33	1.12	.917	.695
I	25	2.72	2.61	2.50	2.40	2.26	2.14	1.98	1.85	1.72	1.53	1.35	1.14	.936	.712
J	30	2.73	2.61	2.51	2.41	2.28	2.15	2.00	1.86	1.73	1.55	1.36	1.15	.946	.723
K	35	2.77	2.65	2.54	2.45	2.31	2.18	2.03	1.89	1.76	1.57	1.39	1.18	.969	.745
L	40	2.77	2.66	2.55	2.44	2.31	2.18	2.03	1.89	1.76	1.58	1.39	1.18	.971	.746
M	50	2.83	2.71	2.60	2.50	2.35	2.22	2.08	1.93	1.80	1.61	1.42	1.21	1.00	.774
N	75	2.90	2.77	2.66	2.55	2.41	2.27	2.12	1.98	1.84	1.65	1.46	1.24	1.03	.804
O	100	2.92	2.80	2.69	2.58	2.43	2.29	2.14	2.00	1.86	1.67	1.48	1.26	1.05	.819
P	150	2.96	2.84	2.73	2.61	2.47	2.33	2.18	2.03	1.89	1.70	1.51	1.29	1.07	.841
Q	200	2.97	2.85	2.73	2.62	2.47	2.33	2.18	2.04	1.89	1.70	1.51	1.29	1.07	.845
		.065	.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00	15.00	
		Acceptable Quality Levels (tightened inspection)													

All AQL values are in percent defective.

↓ Use first sampling plan below arrow, that is, both sample size as well as k value. When sample size equals or exceeds lot size, every item in the lot must be inspected.

TABLE B-2

Standard Deviation Method

Master Table for Reduced Inspection for Plans Based on Variability Unknown
(Single Specification Limit—Form 1)

Sample size code letter	Sample size	Acceptable Quality Levels												
		.04	.065	.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00
		k	k	k	k	k	k	k	k	k	k	k	k	k
B	3	↓	↓	↓	↓	↓	↓	↓	↓	1.12	.958	.765	.566	.341
C	3	↓	↓	↓	↓	↓	↓	↓	↓	1.12	.958	.765	.566	.341
D	3	↓	↓	↓	↓	↓	↓	↓	↓	1.12	.958	.765	.566	.341
E	3	↓	↓	↓	↓	↓	↓	↓	↓	1.12	.958	.765	.566	.341
F	4	↓	↓	↓	↓	↓	↓	1.45	1.34	1.17	1.01	.814	.617	.393
G	5	↓	↓	↓	↓	↓	1.65	1.53	1.40	1.24	1.07	.874	.675	.455
H	7	↓	↓	↓	2.00	1.88	1.75	1.62	1.50	1.33	1.15	.955	.755	.536
I	10	↓	↓	2.24	2.11	1.98	1.84	1.72	1.58	1.41	1.23	1.03	.828	.611
J	10	↓	↓	2.24	2.11	1.98	1.84	1.72	1.58	1.41	1.23	1.03	.828	.611
K	15	2.53	2.42	2.32	2.20	2.06	1.91	1.79	1.65	1.47	1.30	1.09	.886	.664
L	20	2.58	2.47	2.36	2.24	2.11	1.96	1.82	1.69	1.51	1.33	1.12	.917	.695
M	20	2.58	2.47	2.36	2.24	2.11	1.96	1.82	1.69	1.51	1.33	1.12	.917	.695
N	25	2.61	2.50	2.40	2.26	2.14	1.98	1.85	1.72	1.53	1.35	1.14	.936	.712
O	30	2.61	2.51	2.41	2.28	2.15	2.00	1.86	1.73	1.55	1.36	1.15	.946	.723
P	50	2.71	2.60	2.50	2.35	2.22	2.08	1.93	1.80	1.61	1.42	1.21	1.00	.774
Q	75	2.77	2.66	2.55	2.41	2.27	2.12	1.98	1.84	1.65	1.46	1.24	1.03	.804

All AQL values are in percent defective.

↓ Use first sampling plan below arrow, that is, both sample size as well as k value. When sample size equals or exceeds lot size, every item in the lot must be inspected.

Part II

DOUBLE SPECIFICATION LIMIT

B8. SAMPLING PLAN FOR DOUBLE SPECIFICATION LIMIT

This part of the Standard describes the procedures for use with plans for a double specification limit when variability of the lot with respect to the quality characteristic is unknown and the standard deviation method is used.

B8.1 Use of Sampling Plans. To determine whether the lot meets the acceptability criterion with respect to a particular quality characteristic and AQL value(s) the applicable sampling plan shall be used in accordance with the provisions of Section A, General Description of Sampling Plans, and those in this part of the Standard.

B9. SELECTING THE SAMPLING PLAN

A sampling plan for each AQL value shall be selected from Table B-3 or B-4 as follows:

B9.1 Determination of Sample Size Code Letter. The sample size code letter shall be selected from Table A-2 in accordance with paragraph A7.1.

B9.2 Master Sampling Tables. The master sampling tables for plans based on variability unknown for a double specification limit when using the standard deviation method are Tables B-3 and B-4. Table B-3 is used for normal and tightened inspection and Table B-4 for reduced inspection.

B9.3 Obtaining Sampling Plan. A sampling plan consists of a sample size and the associated maximum allowable percent defective(s). The sampling plan to be applied in inspection shall be obtained from Master Table B-3 or B-4.

B9.3.1 Sample Size. The sample size n is shown in the master tables corresponding to each sample size code letter.

B9.3.2 Maximum Allowable Percent Defective. The maximum allowable percent defective for sample estimates of percent defective for the lower, upper, or both specification limits combined, corresponding to the sample size mentioned in paragraph B9.3.1, is shown in the column of the master table corresponding to the applicable AQL value(s). If different AQL's are assigned to each specification limit, designate the maximum allowable percent defective by M_L for the lower limit, and by M_U for the upper limit. If one AQL is assigned to both limits combined, designate the maximum allowable percent defective by M. Table B-3 is entered from the top for normal inspection and from the bottom for tightened inspection. Sampling plans for reduced inspection are provided in Table B-4.

B10. DRAWING OF SAMPLES

Samples shall be selected in accordance with paragraph A7.2.

B11. LOT-BY-LOT ACCEPTABILITY PROCEDURES

B11.1 Acceptability Criterion. The degree of conformance of a quality characteristic with respect to a double specification limit shall be judged by the percent of nonconforming product. The percentage of nonconforming product is estimated by entering Table B-5 with the quality index and the sample size.

B11.2 Computation of Quality Indices. The quality indices $Q_U = (U-\bar{X})/s$ and $Q_L = (\bar{X}-L)/s$ shall be computed, where

U is the upper specification limit,
L is the lower specification limit,
$\bar{X}$ is the sample mean, and
s is the estimate of lot standard deviation.

B11.3 Percent Defective in the Lot. The quality of a lot shall be expressed in terms of the lot percent defective. Its estimate will be designated by p_L, p_U, or p. The estimate p_U indicates conformance with respect to the upper specification limit, p_L with respect to the lower specification limit, and p for both specification limits combined. The estimates p_L and p_U shall be determined by entering Table B-5, respectively with Q_L and Q_U and the sample size. The estimate p shall be determined by adding the corresponding estimated percent defectives p_L and p_U found in the table.

B12. ACCEPTABILITY CRITERION AND SUMMARY FOR OPERATION OF SAMPLING PLANS

B12.1 One AQL value for both Upper and Lower Specification Limit Combined.

B12.1.1 Acceptability Criterion.[4] Compare the estimated lot percent defective $p = p_U + p_L$ with the maximum allowable percent defective M. If p is equal to or less than M, the lot meets the acceptability criterion; if p is greater than M or if either Q_U or Q_L or both are negative, then the lot does not meet the acceptability criterion.

B12.1.2 Summary for Operation of Sampling Plan. In cases where a single AQL value is established for the upper and lower specification limit combined for a single quality characteristic, the following steps summarize the procedures to be used:

(1) Determine the sample size code letter from Table A-2 by using the lot size and the inspection level.

(2) Select plan from Master Table B-3 or B-4. Obtain the sample size n and the maximum allowable percent defective M.

(3) Select at random the sample of n units from the lot; inspect and record the measurement of the quality characteristic on each unit of the sample.

(4) Compute the sample mean $\bar{X}$ and estimate of lot standard deviation s.

(5) Compute the quality indices $Q_U = (U-\bar{X})/s$ and $Q_L = (\bar{X}-L)/s$.

(6) Determine the estimated lot percent defective $p = p_U + p_L$ from Table B-5.

(7) If the estimated lot percent defective p is equal to or less than the maximum allowable percent defective M, the lot meets the acceptability criterion; if p is greater than M or if either Q_U or Q_L or both are negative, then the lot does not meet the acceptability criterion.

B12.2 Different AQL Values for Upper and Lower Specification Limit.

B12.2.1 Acceptability Criteria.[5] Compare the estimated lot percent defectives p_L and p_U with the corresponding maximum allowable percent defectives M_L and M_U; also compare $p = p_L + p_U$ with the larger of M_L and M_U. If p_L is equal to or less than M_L, p_U is equal to or less than M_U, and p is equal to or less than the larger of M_L and M_U, the lot meets the acceptability criteria; otherwise, the lot does not meet the acceptability criteria. If either Q_L or Q_U or both are negative, then the lot does not meet the acceptability criteria.

B12.2.2 Summary for Operation of Sampling Plan. In cases where a different AQL value is established for the upper and lower specification limit for a single quality characteristic, the following steps summarize the procedures to be used:

(1) Determine the sample size code letter from Table A-2 by using the lot size and inspection level.

(2) Select the sampling plan from Master Table B-3 or B-4. Obtain the sample size n and the maximum allowable percent defectives M_U and M_L, corresponding to the AQL values for the upper and lower specification limits, respectively.

(3) Select at random the sample of n units from the lot; inspect and record the measurement of the quality characteristic on each unit in the sample.

(4) Compute the sample mean $\bar{X}$ and estimate a lot standard deviation s.

(5) Compute the quality indices $Q_U = (U-\bar{X})/s$ and $Q_L = (\bar{X}-L)/s$.

(6) Determine the estimated lot percent defectives p_U and p_L, corresponding to the percent defectives above the upper and below the lower specification limits. Also determine the combined percent defective $p = p_U + p_L$.

(7) If all three of the following conditions:

(a) p_U is equal to or less than M_U,

(b) p_L is equal to or less than M_L,

(c) p is equal to or less than the larger of M_L and M_U,

are satisfied, the lot meets the acceptability criteria; otherwise the lot does not meet the acceptability criteria. If either Q_L or Q_U or both are negative, then the lot does not meet the acceptability criteria.

[4] See Example B-3 for a complete example of this procedure.
[5] See Example B-4 for a complete example of this procedure.

EXAMPLE B-3

Example of Calculations

Double Specification Limit

Variability Unknown - Standard Deviation Method

One AQL Value for both Upper and Lower Specification Limit Combined

Example: The minimum temperature of operation for a certain device is specified as 180° F. The maximum temperature is 209° F. A lot of 40 items is submitted for inspection. Inspection Level IV, normal inspection, with AQL = 1% is to be used. From Tables A-2 and B-3 it is seen that a sample of size 5 is required. Suppose the measurements obtained are as follows: 197°, 188°, 184°, 205°, and 201°; and compliance with the acceptability criterion is to be determined.

Line	Information Needed	Value Obtained	Explanation
1	Sample Size: n	5	
2	Sum of Measurements: ΣX	975	
3	Sum of Squared Measurements: ΣX^2	190,435	
4	Correction Factor (CF): $(\Sigma X)^2/n$	190,125	$(975)^2/5$
5	Corrected Sum of Squares (SS): ΣX^2-CF	310	190,435-190,125
6	Variance (V): SS/(n-1)	77.5	310/4
7	Estimate of Lot Standard Deviation s: $\sqrt{V}$	8.81	$\sqrt{77.5}$
8	Sample Mean $\bar{X}$: $\Sigma X/n$	195	975/5
9	Upper Specification Limit: U	209	
10	Lower Specification Limit: L	180	
11	Quality Index: $Q_U = (U-\bar{X})/s$	1.59	(209-195)/8.81
12	Quality Index: $Q_L = (\bar{X}-L)/s$	1.70	(195-180)/8.81
13	Est. of Lot Percent Def. above U: p_U	2.19%	See Table B-5
14	Est. of Lot Percent Def. below L: p_L	.66%	See Table B-5
15	Total Est. Percent Def. in Lot: $p = p_U + p_L$	2.85%	2.19% + .66%
16	Max. Allowable Percent Def.: M	3.32%	See Table B-3
17	Acceptability Criterion: Compare $p = p_U + p_L$ with M	2.85% < 3.32%	See Para. B12.1.2 (7)

The lot meets the acceptability criterion, since $p = p_U + p_L$ is less than M.

EXAMPLE B-4

Example of Calculations

Double Specification Limit

Variability Unknown - Standard Deviation Method

Different AQL Values for Upper and Lower Specification Limits

Example: The minimum temperature of operation for a certain device is specified as 180° F. The maximum temperature is 209° F. A lot of 40 items is submitted for inspection. Inspection Level IV, normal inspection, with AQL = 1% for the upper and AQL = 2.5% for the lower specification limit is to be used. From Tables A-2 and B-3 it is seen that a sample of size 5 is required. Suppose the measurements obtained are as follows: 197°, 188°, 184°, 205°, and 201°; and compliance with the acceptability criteria is to be determined.

Line	Information Needed	Value Obtained	Explanation
1	Sample Size: n	5	
2	Sum of Measurements: ΣX	975	
3	Sum of Squared Measurements: ΣX^2	190,435	
4	Correction Factor (CF): $(\Sigma X)^2/n$	190,125	$(975)^2/5$
5	Corrected Sum of Squares (SS): $\Sigma X^2 - CF$	310	190,435-190,125
6	Variance (V): $SS/(n-1)$	77.5	310/4
7	Estimate of Lot Standard Deviation s: $\sqrt{V}$	8.81	$\sqrt{77.5}$
8	Sample Mean $\bar{X}$: $\Sigma X/n$	195	975/5
9	Upper Specification Limit: U	209	
10	Lower Specification Limit: L	180	
11	Quality Index: $Q_U = (U-\bar{X})/s$	1.59	(209-195)/8.81
12	Quality Index: $Q_L = (\bar{X}-L)/s$	1.70	(195-180)/8.81
13	Est. of Lot Percent Def. above U: p_U	2.19%	See Table B-5
14	Est. of Lot Percent Def. below L: p_L	.66%	See Table B-5
15	Total Est. Percent Def. in Lot: $p = p_U + p_L$	2.85%	2.19% + .66%
16	Max. Allowable Percent Def. above U: M_U	3.32%	See Table B-3
17	Max. Allowable Percent Def. below L: M_L	9.80%	See Table B-3
18	Acceptability Criteria: (a) Compare p_U with M_U	2.19% < 3.32%	See Para. B12.2.2(7)(a)
	(b) Compare p_L with M_L	.66% < 9.80%	See Para. B12.2.2(7)(b)
	(c) Compare p with M_L	2.85% < 9.80%	See Para. B12.2.2(7)(c)

The lot meets the acceptability criteria, since 18(a), (b), and (c) are satisfied; i.e., $p_U < M_U$, $p_L < M_L$ and $p < M_L$.

TABLE B-3

Standard Deviation Method

Master Table for Normal and Tightened Inspection for Plans Based on Variability Unknown
(Double Specification Limit and Form 2—Single Specification Limit)

Sample size code letter	Sample size	Acceptable Quality Levels (normal inspection)													
		.04	.065	.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00	15.00
		M	M	M	M	M	M	M	M	M	M	M	M	M	M
B	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	7.59	18.86	26.94	33.69	40.47
C	4								1.53	5.50	10.92	16.45	22.86	29.45	36.90
D	5							1.33	3.32	5.83	9.80	14.39	20.19	26.56	33.99
E	7					0.422	1.06	2.14	3.55	5.35	8.40	12.20	17.35	23.29	30.50
F	10				0.349	0.716	1.30	2.17	3.26	4.77	7.29	10.54	15.17	20.74	27.57
G	15	0.099	0.186	0.312	0.503	0.818	1.31	2.11	3.05	4.31	6.56	9.46	13.71	18.94	25.61
H	20	0.135	0.228	0.365	0.544	0.846	1.29	2.05	2.95	4.09	6.17	8.92	12.99	18.03	24.53
I	25	0.155	0.250	0.380	0.551	0.877	1.29	2.00	2.86	3.97	5.97	8.63	12.57	17.51	23.97
J	30	0.179	0.280	0.413	0.581	0.879	1.29	1.98	2.83	3.91	5.86	8.47	12.36	17.24	23.58
K	35	0.170	0.264	0.388	0.535	0.847	1.23	1.87	2.68	3.70	5.57	8.10	11.87	16.65	22.91
L	40	0.179	0.275	0.401	0.566	0.873	1.26	1.88	2.71	3.72	5.58	8.09	11.85	16.61	22.86
M	50	0.163	0.250	0.363	0.503	0.789	1.17	1.71	2.49	3.45	5.20	7.61	11.23	15.87	22.00
N	75	0.147	0.228	0.330	0.467	0.720	1.07	1.60	2.29	3.20	4.87	7.15	10.63	15.13	21.11
O	100	0.145	0.220	0.317	0.447	0.689	1.02	1.53	2.20	3.07	4.69	6.91	10.32	14.75	20.66
P	150	0.134	0.203	0.293	0.413	0.638	0.949	1.43	2.05	2.89	4.43	6.57	9.88	14.20	20.02
Q	200	0.135	0.204	0.294	0.414	0.637	0.945	1.42	2.04	2.87	4.40	6.53	9.81	14.12	19.92
		.065	.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00	15.00	
		Acceptability Quality Levels (tightened inspection)													

All AQL and table values are in percent defective.

↓ Use first sampling plan below arrow, that is, both sample size as well as M value. When sample size equals or exceeds lot size, every item in the lot must be inspected.

Standard Deviation Method

TABLE B-4

Master Table for Reduced Inspection for Plans Based on Variability Unknown
(Double Specification Limit and Form 2—Single Specification Limit)

Sample size code letter	Sample size	Acceptable Quality Levels												
		.04	.065	.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00
		M	M	M	M	M	M	M	M	M	M	M	M	M
B	3									7.59	18.86	26.94	33.69	40.47
C	3									7.59	18.86	26.94	33.69	40.47
D	3									7.59	18.86	26.94	33.69	40.47
E	3									7.59	18.86	26.94	33.69	40.47
F	4							1.53	5.50	10.92	16.45	22.86	29.45	36.90
G	5						1.33	3.32	5.83	9.80	14.39	20.19	26.56	33.99
H	7				0.422	1.06	2.14	3.55	5.35	8.40	12.20	17.35	23.29	30.50
I	10			0.349	0.716	1.30	2.17	3.26	4.77	7.29	10.54	15.17	20.74	27.57
J	10			0.349	0.716	1.30	2.17	3.26	4.77	7.29	10.54	15.17	20.74	27.57
K	15	0.186	0.312	0.503	0.818	1.31	2.11	3.05	4.31	6.56	9.46	13.71	18.94	25.61
L	20	0.228	0.365	0.544	0.846	1.29	2.05	2.95	4.09	6.17	8.92	12.99	18.03	24.53
M	20	0.228	0.365	0.544	0.846	1.29	2.05	2.95	4.09	6.17	8.92	12.99	18.03	24.53
N	25	0.250	0.380	0.551	0.877	1.29	2.00	2.86	3.97	5.97	8.63	12.57	17.51	23.97
O	30	0.280	0.413	0.581	0.879	1.29	1.98	2.83	3.91	5.86	8.47	12.36	17.24	23.58
P	50	0.250	0.363	0.503	0.789	1.17	1.71	2.49	3.45	5.20	7.61	11.23	15.87	22.00
Q	75	0.228	0.330	0.467	0.720	1.07	1.60	2.29	3.20	4.87	7.15	10.63	15.13	21.11

All AQL and table values are in percent defective.

↓ Use first sampling plan below arrow, that is, both sample size as well as M value. When sample size equals or exceeds lot size, every item in the lot must be inspected.

TABLE B-5

Table for Estimating the Lot Percent Defective Using Standard Deviation Method[1]

Q_U or Q_L	Sample Size 3	4	5	7	10	15	20	25	30	35	40	50	75	100	150	200
0	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
.1	47.24	46.67	46.44	46.26	46.16	46.10	46.08	46.06	46.05	46.05	46.04	46.04	46.03	46.03	46.02	46.02
.2	44.46	43.33	42.90	42.54	42.35	42.24	42.19	42.16	42.15	42.13	42.13	42.11	42.10	42.09	42.08	42.08
.3	41.63	40.00	39.37	38.87	38.60	38.44	38.37	38.33	38.31	38.29	38.28	38.27	38.25	38.24	38.22	38.22
.31	41.35	39.67	39.02	38.50	38.23	38.06	37.99	37.95	37.93	37.91	37.90	37.89	37.87	37.86	37.84	37.84
.32	41.06	39.33	38.67	38.14	37.86	37.69	37.62	37.58	37.55	37.54	37.52	37.51	37.49	37.48	37.46	37.46
.33	40.77	39.00	38.32	37.78	37.49	37.31	37.24	37.20	37.18	37.16	37.15	37.13	37.11	37.10	37.09	37.08
.34	40.49	38.67	37.97	37.42	37.12	36.94	36.87	36.83	36.80	36.78	36.77	36.75	36.73	36.72	36.71	36.71
.35	40.20	38.33	37.62	37.06	36.75	36.57	36.49	36.45	36.43	36.41	36.40	36.38	36.36	36.35	36.33	36.33
.36	39.91	38.00	37.28	36.69	36.38	36.20	36.12	36.08	36.05	36.04	36.02	36.01	35.98	35.97	35.96	35.96
.37	39.62	37.67	36.93	36.33	36.02	35.83	35.75	35.71	35.68	35.66	35.65	35.63	35.61	35.60	35.59	35.58
.38	39.33	37.33	36.58	35.98	35.65	35.46	35.38	35.34	35.31	35.29	35.28	35.26	35.24	35.23	35.22	35.21
.39	39.03	37.00	36.23	35.62	35.29	35.10	35.01	34.97	34.94	34.93	34.91	34.89	34.87	34.86	34.85	34.84
.40	38.74	36.67	35.88	35.26	34.93	34.73	34.65	34.60	34.58	34.56	34.54	34.53	34.50	34.49	34.48	34.47
.41	38.45	36.33	35.54	34.90	34.57	34.37	34.28	34.24	34.21	34.19	34.18	34.16	34.13	34.12	34.11	34.10
.42	38.15	36.00	35.19	34.55	34.21	34.00	33.92	33.87	33.85	33.83	33.81	33.79	33.77	33.76	33.74	33.74
.43	37.85	35.67	34.85	34.19	33.85	33.64	33.56	33.51	33.48	33.46	33.45	33.43	33.40	33.39	33.38	33.37
.44	37.56	35.33	34.50	33.84	33.49	33.28	33.20	33.15	33.12	33.10	33.09	33.07	33.04	33.03	33.02	33.01
.45	37.26	35.00	34.16	33.49	33.13	32.92	32.84	32.79	32.76	32.74	32.73	32.71	32.68	32.67	32.66	32.65
.46	36.96	34.67	33.82	33.13	32.78	32.57	32.48	32.43	32.40	32.38	32.37	32.35	32.32	32.31	32.30	32.29
.47	36.66	34.33	33.47	32.78	32.42	32.21	32.12	32.07	32.04	32.02	32.01	31.99	31.96	31.95	31.94	31.93
.48	36.35	34.00	33.12	32.43	32.07	31.85	31.77	31.72	31.69	31.67	31.65	31.63	31.61	31.60	31.58	31.58
.49	36.05	33.67	32.78	32.08	31.72	31.50	31.41	31.36	31.33	31.31	31.30	31.28	31.25	31.24	31.23	31.22
.50	35.75	33.33	32.44	31.74	31.37	31.15	31.06	31.01	30.98	30.96	30.95	30.93	30.90	30.89	30.87	30.87
.51	35.44	33.00	32.10	31.39	31.02	30.80	30.71	30.66	30.63	30.61	30.60	30.57	30.55	30.54	30.52	30.52
.52	35.13	32.67	31.76	31.04	30.67	30.45	30.36	30.31	30.28	30.26	30.25	30.23	30.20	30.19	30.17	30.17
.53	34.82	32.33	31.42	30.70	30.32	30.10	30.01	29.96	29.93	29.91	29.90	29.88	29.85	29.84	29.83	29.82
.54	34.51	32.00	31.08	30.36	29.98	29.76	29.67	29.62	29.59	29.57	29.55	29.53	29.51	29.49	29.48	29.48
.55	34.20	31.67	30.74	30.01	29.64	29.41	29.32	29.27	29.24	29.22	29.21	29.19	29.16	29.15	29.14	29.13
.56	33.88	31.33	30.40	29.67	29.29	29.07	28.98	28.93	28.90	28.88	28.87	28.85	28.82	28.81	28.79	28.79
.57	33.57	31.00	30.06	29.33	28.95	28.73	28.64	28.59	28.56	28.54	28.53	28.51	28.48	28.47	28.45	28.45
.58	33.25	30.67	29.73	28.99	28.61	28.39	28.30	28.25	28.22	28.20	28.19	28.17	28.14	28.13	28.12	28.11
.59	32.93	30.33	29.39	28.66	28.28	28.05	27.96	27.92	27.89	27.87	27.85	27.83	27.81	27.79	27.78	27.77
.60	32.61	30.00	29.05	28.32	27.94	27.72	27.63	27.58	27.55	27.53	27.52	27.50	27.47	27.46	27.45	27.44
.61	32.28	29.67	28.72	27.98	27.60	27.39	27.30	27.25	27.22	27.20	27.18	27.16	27.14	27.13	27.11	27.11
.62	31.96	29.33	28.39	27.65	27.27	27.05	26.96	26.92	26.89	26.87	26.85	26.83	26.81	26.80	26.78	26.78
.63	31.63	29.00	28.05	27.32	26.94	26.72	26.63	26.59	26.56	26.54	26.52	26.50	26.48	26.47	26.45	26.45
.64	31.30	28.67	27.72	26.99	26.61	26.39	26.31	26.26	26.23	26.21	26.20	26.18	26.15	26.14	26.13	26.12
.65	30.97	28.33	27.39	26.66	26.28	26.07	25.98	25.93	25.90	25.88	25.87	25.85	25.83	25.82	25.80	25.80
.66	30.63	28.00	27.06	26.33	25.96	25.74	25.66	25.61	25.58	25.56	25.55	25.53	25.51	25.49	25.48	25.48
.67	30.30	27.67	26.73	26.00	25.63	25.42	25.33	25.29	25.26	25.24	25.23	25.21	25.19	25.17	25.16	25.16
.68	29.96	27.33	26.40	25.68	25.31	25.10	25.01	24.97	24.94	24.92	24.91	24.89	24.87	24.86	24.84	24.84
.69	29.61	27.00	26.07	25.35	24.99	24.78	24.70	24.65	24.62	24.60	24.59	24.57	24.55	24.54	24.53	24.52

Q_U or Q_L	Sample Size 3	4	5	7	10	15	20	25	30	35	40	50	75	100	150	200
.70	29.27	26.67	25.74	25.00	24.67	24.46	24.38	24.33	24.31	24.29	24.28	24.26	24.24	24.23	24.21	24.21
.71	28.92	26.33	25.41	24.71	24.35	24.15	24.06	24.02	23.99	23.98	23.96	23.95	23.92	23.91	23.90	23.90
.72	28.57	26.00	25.09	24.39	24.03	23.83	23.75	23.71	23.68	23.67	23.65	23.64	23.61	23.60	23.59	23.59
.73	28.22	25.67	24.76	24.07	23.72	23.52	23.44	23.40	23.37	23.36	23.34	23.33	23.31	23.30	23.29	23.28
.74	27.86	25.33	24.44	23.75	23.41	23.21	23.13	23.09	23.07	23.05	23.04	23.02	23.00	22.99	22.98	22.98
.75	27.50	25.00	24.11	23.44	23.10	22.90	22.83	22.79	22.76	22.75	22.73	22.72	22.70	22.69	22.68	22.67
.76	27.13	24.67	23.79	23.12	22.79	22.60	22.52	22.48	22.46	22.44	22.43	22.42	22.40	22.39	22.38	22.37
.77	26.77	24.33	23.47	22.81	22.48	22.30	22.22	22.18	22.16	22.14	22.13	22.12	22.10	22.09	22.08	22.08
.78	26.39	24.00	23.15	22.50	22.18	21.99	21.92	21.89	21.86	21.85	21.84	21.82	21.80	21.79	21.78	21.78
.79	26.02	23.67	22.83	22.19	21.87	21.70	21.63	21.59	21.57	21.55	21.54	21.53	21.51	21.50	21.49	21.49
.80	25.64	23.33	22.51	21.88	21.57	21.40	21.33	21.29	21.27	21.26	21.25	21.23	21.22	21.21	21.20	21.20
.81	25.25	23.00	22.19	21.58	21.27	21.10	21.04	21.00	20.98	20.97	20.96	20.94	20.93	20.92	20.91	20.91
.82	24.86	22.67	21.87	21.27	20.98	20.81	20.75	20.71	20.69	20.68	20.67	20.65	20.64	20.63	20.62	20.62
.83	24.47	22.33	21.56	20.97	20.68	20.52	20.46	20.42	20.40	20.39	20.38	20.37	20.35	20.35	20.34	20.34
.84	24.07	22.00	21.24	20.67	20.39	20.23	20.17	20.14	20.12	20.11	20.10	20.09	20.07	20.06	20.06	20.05
.85	23.67	21.67	20.93	20.37	20.10	19.94	19.89	19.86	19.84	19.82	19.82	19.80	19.79	19.78	19.78	19.77
.86	23.26	21.33	20.62	20.07	19.81	19.66	19.60	19.57	19.56	19.54	19.54	19.53	19.51	19.51	19.50	19.50
.87	22.84	21.00	20.31	19.78	19.52	19.38	19.32	19.30	19.28	19.27	19.26	19.25	19.24	19.23	19.22	19.22
.88	22.42	20.67	20.00	19.48	19.23	19.10	19.04	19.02	19.00	18.99	18.98	18.98	18.96	18.96	18.95	18.95
.89	21.99	20.33	19.69	19.19	18.95	18.82	18.77	18.74	18.73	18.72	18.71	18.70	18.69	18.69	18.68	18.68
.90	21.55	20.00	19.38	18.90	18.67	18.54	18.50	18.47	18.46	18.45	18.44	18.43	18.42	18.42	18.41	18.41
.91	21.11	19.67	19.07	18.61	18.39	18.27	18.22	18.20	18.19	18.18	18.17	18.17	18.16	18.15	18.15	18.15
.92	20.66	19.33	18.77	18.33	18.11	18.00	17.96	17.94	17.92	17.92	17.91	17.90	17.89	17.89	17.89	17.88
.93	20.20	19.00	18.46	18.04	17.84	17.73	17.69	17.67	17.66	17.65	17.65	17.64	17.63	17.63	17.62	17.62
.94	19.74	18.67	18.16	17.76	17.57	17.46	17.43	17.41	17.40	17.39	17.39	17.38	17.37	17.37	17.36	17.36
.95	19.25	18.33	17.86	17.48	17.29	17.20	17.17	17.15	17.14	17.13	17.13	17.12	17.12	17.11	17.11	17.11
.96	18.76	18.00	17.56	17.20	17.03	16.94	16.91	16.89	16.88	16.88	16.87	16.87	16.86	16.86	16.86	16.85
.97	18.25	17.67	17.25	16.92	16.76	16.68	16.65	16.63	16.63	16.62	16.62	16.61	16.61	16.61	16.60	16.60
.98	17.74	17.33	16.96	16.65	16.49	16.42	16.39	16.38	16.37	16.37	16.37	16.36	16.36	16.36	16.36	16.36
.99	17.21	17.00	16.66	16.37	16.23	16.16	16.14	16.13	16.12	16.12	16.12	16.12	16.11	16.11	16.11	16.11
1.00	16.67	16.67	16.36	16.10	15.97	15.91	15.89	15.88	15.88	15.87	15.87	15.87	15.87	15.87	15.87	15.87
1.01	16.11	16.33	16.07	15.83	15.72	15.66	15.64	15.63	15.63	15.63	15.63	15.63	15.62	15.62	15.62	15.62
1.02	15.53	16.00	15.78	15.56	15.46	15.41	15.40	15.39	15.39	15.39	15.39	15.38	15.38	15.38	15.38	15.38
1.03	14.93	15.67	15.48	15.30	15.21	15.17	15.15	15.15	15.15	15.15	15.15	15.15	15.15	15.15	15.15	15.15
1.04	14.31	15.33	15.19	15.03	14.96	14.92	14.91	14.91	14.91	14.91	14.91	14.91	14.91	14.91	14.91	14.91
1.05	13.66	15.00	14.91	14.77	14.71	14.68	14.67	14.67	14.67	14.67	14.68	14.68	14.68	14.68	14.68	14.68
1.06	12.98	14.67	14.62	14.51	14.46	14.44	14.44	14.44	14.44	14.44	14.44	14.45	14.45	14.45	14.45	14.45
1.07	12.27	14.33	14.33	14.26	14.22	14.20	14.20	14.21	14.21	14.21	14.21	14.22	14.22	14.22	14.22	14.23
1.08	11.51	14.00	14.05	14.00	13.97	13.97	13.97	13.98	13.98	13.98	13.99	13.99	13.99	14.00	14.00	14.00
1.09	10.71	13.67	13.76	13.75	13.73	13.74	13.74	13.75	13.75	13.76	13.76	13.77	13.77	13.77	13.78	13.78

[1] Values tabulated are read in percent.

TABLE B-5—Continued

Table for Estimating the Lot Percent Defective Using Standard Deviation Method

Q_U or Q_L	Sample Size 3	4	5	7	10	15	20	25	30	35	40	50	75	100	150	200
1.10	9.84	13.33	13.48	13.49	13.50	13.51	13.52	13.52	13.53	13.54	13.54	13.54	13.55	13.55	13.56	13.56
1.11	8.89	13.00	13.20	13.25	13.26	13.28	13.29	13.30	13.31	13.31	13.32	13.32	13.33	13.34	13.34	13.34
1.12	7.82	12.67	12.93	13.00	13.03	13.05	13.07	13.08	13.09	13.10	13.10	13.11	13.12	13.12	13.12	13.13
1.13	6.60	12.33	12.65	12.75	12.80	12.83	12.85	12.86	12.87	12.88	12.89	12.89	12.90	12.91	12.91	12.92
1.14	5.08	12.00	12.37	12.51	12.57	12.61	12.63	12.65	12.66	12.67	12.67	12.68	12.69	12.70	12.70	12.70
1.15	0.29	11.67	12.10	12.27	12.34	12.39	12.42	12.44	12.45	12.46	12.46	12.47	12.48	12.49	12.49	12.50
1.16	0.00	11.33	11.83	12.03	12.12	12.18	12.21	12.22	12.24	12.25	12.25	12.26	12.28	12.28	12.29	12.29
1.17	0.00	11.00	11.56	11.79	11.90	11.96	12.00	12.02	12.03	12.04	12.05	12.06	12.07	12.08	12.08	12.09
1.18	0.00	10.67	11.29	11.56	11.68	11.75	11.79	11.81	11.82	11.84	11.84	11.85	11.87	11.88	11.88	11.89
1.19	0.00	10.33	11.02	11.33	11.46	11.54	11.58	11.61	11.62	11.63	11.64	11.65	11.67	11.68	11.69	11.69
1.20	0.00	10.00	10.75	11.10	11.24	11.34	11.38	11.41	11.42	11.43	11.44	11.46	11.47	11.48	11.49	11.49
1.21	0.00	9.67	10.50	10.87	11.02	11.13	11.18	11.21	11.22	11.24	11.25	11.26	11.28	11.29	11.30	11.30
1.22	0.00	9.33	10.23	10.65	10.82	10.93	10.98	11.01	11.03	11.04	11.05	11.07	11.09	11.09	11.10	11.11
1.23	0.00	9.00	9.97	10.42	10.61	10.73	10.78	10.81	10.84	10.85	10.86	10.88	10.90	10.91	10.91	10.92
1.24	0.00	8.67	9.72	10.20	10.41	10.53	10.59	10.62	10.64	10.66	10.67	10.69	10.71	10.72	10.73	10.73
1.25	0.00	8.33	9.46	9.98	10.21	10.34	10.40	10.43	10.46	10.47	10.48	10.50	10.52	10.53	10.54	10.55
1.26	0.00	8.00	9.21	9.77	10.00	10.15	10.21	10.25	10.27	10.29	10.30	10.32	10.34	10.35	10.36	10.37
1.27	0.00	7.67	8.96	9.55	9.81	9.96	10.02	10.06	10.09	10.10	10.12	10.13	10.16	10.17	10.18	10.19
1.28	0.00	7.33	8.71	9.34	9.61	9.77	9.84	9.88	9.90	9.92	9.94	9.95	9.98	9.99	10.00	10.01
1.29	0.00	7.00	8.46	9.13	9.42	9.58	9.65	9.70	9.72	9.74	9.76	9.78	9.80	9.82	9.83	9.83
1.30	0.00	6.67	8.21	8.93	9.22	9.40	9.48	9.52	9.55	9.57	9.58	9.60	9.63	9.64	9.65	9.66
1.31	0.00	6.33	7.97	8.72	9.03	9.22	9.30	9.34	9.37	9.39	9.41	9.43	9.46	9.47	9.48	9.49
1.32	0.00	6.00	7.73	8.52	8.85	9.04	9.12	9.17	9.20	9.22	9.24	9.26	9.29	9.30	9.31	9.32
1.33	0.00	5.67	7.49	8.32	8.66	8.86	8.95	9.00	9.03	9.05	9.07	9.09	9.12	9.13	9.15	9.15
1.34	0.00	5.33	7.25	8.12	8.48	8.69	8.78	8.83	8.86	8.88	8.90	8.92	8.95	8.97	8.98	8.99
1.35	0.00	5.00	7.02	7.92	8.30	8.52	8.61	8.66	8.69	8.72	8.74	8.76	8.79	8.81	8.82	8.83
1.36	0.00	4.67	6.79	7.73	8.12	8.35	8.44	8.50	8.53	8.55	8.57	8.60	8.63	8.65	8.66	8.67
1.37	0.00	4.33	6.56	7.54	7.95	8.18	8.28	8.33	8.37	8.39	8.41	8.44	8.47	8.49	8.50	8.51
1.38	0.00	4.00	6.33	7.35	7.77	8.01	8.12	8.17	8.21	8.24	8.25	8.28	8.31	8.33	8.35	8.35
1.39	0.00	3.67	6.10	7.17	7.60	7.85	7.96	8.01	8.05	8.08	8.10	8.12	8.16	8.18	8.19	8.20
1.40	0.00	3.33	5.88	6.98	7.44	7.69	7.80	7.86	7.90	7.92	7.94	7.97	8.01	8.02	8.04	8.05
1.41	0.00	3.00	5.66	6.80	7.27	7.53	7.64	7.70	7.74	7.77	7.79	7.82	7.86	7.87	7.89	7.90
1.42	0.00	2.67	5.44	6.62	7.10	7.37	7.49	7.55	7.59	7.62	7.64	7.67	7.71	7.73	7.74	7.75
1.43	0.00	2.33	5.23	6.45	6.94	7.22	7.34	7.40	7.44	7.47	7.50	7.52	7.56	7.58	7.60	7.61
1.44	0.00	2.00	5.01	6.27	6.78	7.07	7.19	7.26	7.30	7.33	7.35	7.38	7.42	7.44	7.46	7.47
1.45	0.00	1.67	4.81	6.10	6.63	6.92	7.04	7.11	7.15	7.18	7.21	7.24	7.28	7.30	7.31	7.33
1.46	0.00	1.33	4.60	5.93	6.47	6.77	6.90	6.97	7.01	7.04	7.07	7.10	7.14	7.16	7.18	7.19
1.47	0.00	1.00	4.39	5.77	6.32	6.63	6.75	6.83	6.87	6.90	6.93	6.96	7.00	7.02	7.04	7.05
1.48	0.00	.67	4.19	5.60	6.17	6.48	6.61	6.69	6.73	6.77	6.79	6.82	6.86	6.88	6.90	6.91
1.49	0.00	.33	3.99	5.44	6.02	6.34	6.48	6.55	6.60	6.63	6.65	6.69	6.73	6.75	6.77	6.78

Q_U or Q_L	Sample Size 3	4	5	7	10	15	20	25	30	35	40	50	75	100	150	200
1.50	0.00	0.00	3.80	5.28	5.87	6.20	6.34	6.41	6.46	6.50	6.52	6.55	6.60	6.62	6.64	6.65
1.51	0.00	0.00	3.61	5.13	5.73	6.06	6.20	6.28	6.33	6.36	6.39	6.42	6.47	6.49	6.51	6.52
1.52	0.00	0.00	3.42	4.97	5.59	5.93	6.07	6.15	6.20	6.23	6.26	6.29	6.34	6.36	6.38	6.39
1.53	0.00	0.00	3.23	4.82	5.45	5.80	5.94	6.02	6.07	6.11	6.13	6.17	6.21	6.24	6.26	6.27
1.54	0.00	0.00	3.05	4.67	5.31	5.67	5.81	5.89	5.95	5.98	6.01	6.04	6.09	6.11	6.13	6.15
1.55	0.00	0.00	2.87	4.52	5.18	5.54	5.69	5.77	5.82	5.86	5.88	5.92	5.97	5.99	6.01	6.02
1.56	0.00	0.00	2.69	4.38	5.05	5.41	5.56	5.65	5.70	5.74	5.76	5.80	5.85	5.87	5.89	5.90
1.57	0.00	0.00	2.52	4.24	4.92	5.29	5.44	5.53	5.58	5.62	5.64	5.68	5.73	5.75	5.78	5.79
1.58	0.00	0.00	2.35	4.10	4.79	5.16	5.32	5.41	5.46	5.50	5.53	5.56	5.61	5.64	5.66	5.67
1.59	0.00	0.00	2.19	3.96	4.66	5.04	5.20	5.29	5.34	5.38	5.41	5.45	5.50	5.52	5.54	5.56
1.60	0.00	0.00	2.03	3.83	4.54	4.92	5.09	5.17	5.23	5.27	5.30	5.33	5.38	5.41	5.43	5.44
1.61	0.00	0.00	1.87	3.69	4.41	4.81	4.97	5.06	5.12	5.16	5.18	5.22	5.27	5.30	5.32	5.33
1.62	0.00	0.00	1.72	3.57	4.30	4.69	4.86	4.95	5.01	5.04	5.07	5.11	5.16	5.19	5.21	5.23
1.63	0.00	0.00	1.57	3.44	4.18	4.58	4.75	4.84	4.90	4.94	4.97	5.01	5.06	5.08	5.11	5.12
1.64	0.00	0.00	1.42	3.31	4.06	4.47	4.64	4.73	4.79	4.83	4.86	4.90	4.95	4.98	5.00	5.01
1.65	0.00	0.00	1.28	3.19	3.95	4.36	4.53	4.62	4.68	4.72	4.75	4.79	4.85	4.87	4.90	4.91
1.66	0.00	0.00	1.15	3.07	3.84	4.25	4.43	4.52	4.58	4.62	4.65	4.69	4.74	4.77	4.80	4.81
1.67	0.00	0.00	1.02	2.95	3.73	4.15	4.32	4.42	4.48	4.52	4.55	4.59	4.64	4.67	4.70	4.71
1.68	0.00	0.00	0.89	2.84	3.62	4.05	4.22	4.32	4.38	4.42	4.45	4.49	4.55	4.57	4.60	4.61
1.69	0.00	0.00	0.77	2.73	3.52	3.94	4.12	4.22	4.28	4.32	4.35	4.39	4.45	4.47	4.50	4.51
1.70	0.00	0.00	0.66	2.62	3.41	3.84	4.02	4.12	4.18	4.22	4.25	4.30	4.35	4.38	4.41	4.42
1.71	0.00	0.00	0.55	2.51	3.31	3.75	3.93	4.02	4.09	4.13	4.16	4.20	4.26	4.29	4.31	4.32
1.72	0.00	0.00	0.45	2.41	3.21	3.65	3.83	3.93	3.99	4.04	4.07	4.11	4.17	4.19	4.22	4.23
1.73	0.00	0.00	0.36	2.30	3.11	3.56	3.74	3.84	3.90	3.94	3.98	4.02	4.08	4.10	4.13	4.14
1.74	0.00	0.00	0.27	2.20	3.02	3.46	3.65	3.75	3.81	3.85	3.89	3.93	3.99	4.01	4.04	4.05
1.75	0.00	0.00	0.19	2.11	2.93	3.37	3.56	3.66	3.72	3.77	3.80	3.84	3.90	3.93	3.95	3.97
1.76	0.00	0.00	0.12	2.01	2.83	3.28	3.47	3.57	3.63	3.68	3.71	3.76	3.81	3.84	3.87	3.88
1.77	0.00	0.00	0.06	1.92	2.74	3.20	3.38	3.48	3.55	3.59	3.63	3.67	3.73	3.76	3.78	3.80
1.78	0.00	0.00	0.02	1.83	2.66	3.11	3.30	3.40	3.47	3.51	3.54	3.59	3.64	3.67	3.70	3.71
1.79	0.00	0.00	0.00	1.74	2.57	3.03	3.21	3.32	3.38	3.43	3.46	3.51	3.56	3.59	3.63	3.63
1.80	0.00	0.00	0.00	1.65	2.49	2.94	3.13	3.24	3.30	3.35	3.38	3.43	3.48	3.51	3.54	3.55
1.81	0.00	0.00	0.00	1.57	2.40	2.86	3.05	3.16	3.22	3.27	3.30	3.35	3.40	3.43	3.46	3.47
1.82	0.00	0.00	0.00	1.49	2.32	2.79	2.98	3.08	3.15	3.19	3.22	3.27	3.33	3.36	3.38	3.40
1.83	0.00	0.00	0.00	1.41	2.25	2.71	2.90	3.00	3.07	3.11	3.15	3.19	3.25	3.28	3.31	3.32
1.84	0.00	0.00	0.00	1.34	2.17	2.63	2.82	2.93	2.99	3.04	3.07	3.12	3.18	3.21	3.23	3.25
1.85	0.00	0.00	0.00	1.26	2.09	2.56	2.75	2.85	2.92	2.97	3.00	3.05	3.10	3.13	3.16	3.17
1.86	0.00	0.00	0.00	1.19	2.02	2.48	2.68	2.78	2.85	2.89	2.93	2.97	3.03	3.06	3.09	3.10
1.87	0.00	0.00	0.00	1.12	1.95	2.41	2.61	2.71	2.78	2.82	2.86	2.90	2.96	2.99	3.02	3.03
1.88	0.00	0.00	0.00	1.06	1.88	2.34	2.54	2.64	2.71	2.75	2.79	2.83	2.89	2.92	2.95	2.96
1.89	0.00	0.00	0.00	0.99	1.81	2.28	2.47	2.57	2.64	2.69	2.72	2.77	2.83	2.85	2.88	2.90

TABLE B-5—Continued

Table for Estimating the Lot Percent Defective Using Standard Deviation Method

Q_U or Q_L	Sample Size 3	4	5	7	10	15	20	25	30	35	40	50	75	100	150	200
1.90	0.00	0.00	0.00	0.93	1.75	2.21	2.40	2.51	2.57	2.62	2.65	2.70	2.76	2.79	2.82	2.83
1.91	0.00	0.00	0.00	0.87	1.68	2.14	2.34	2.44	2.51	2.56	2.59	2.63	2.69	2.72	2.75	2.77
1.92	0.00	0.00	0.00	0.81	1.62	2.08	2.27	2.38	2.45	2.49	2.52	2.57	2.63	2.66	2.69	2.70
1.93	0.00	0.00	0.00	0.76	1.56	2.02	2.21	2.32	2.38	2.43	2.46	2.51	2.57	2.60	2.62	2.64
1.94	0.00	0.00	0.00	0.70	1.50	1.96	2.15	2.25	2.32	2.37	2.40	2.45	2.51	2.54	2.56	2.58
1.95	0.00	0.00	0.00	0.65	1.44	1.90	2.09	2.19	2.26	2.31	2.34	2.39	2.45	2.48	2.50	2.52
1.96	0.00	0.00	0.00	0.60	1.38	1.84	2.03	2.14	2.20	2.25	2.28	2.33	2.39	2.42	2.44	2.46
1.97	0.00	0.00	0.00	0.56	1.33	1.78	1.97	2.08	2.14	2.19	2.22	2.27	2.33	2.36	2.39	2.40
1.98	0.00	0.00	0.00	0.51	1.27	1.73	1.92	2.02	2.09	2.13	2.17	2.21	2.27	2.30	2.33	2.34
1.99	0.00	0.00	0.00	0.47	1.22	1.67	1.86	1.97	2.03	2.08	2.11	2.16	2.22	2.25	2.27	2.29
2.00	0.00	0.00	0.00	0.43	1.17	1.62	1.81	1.91	1.98	2.03	2.06	2.10	2.16	2.19	2.22	2.23
2.01	0.00	0.00	0.00	0.39	1.12	1.57	1.76	1.86	1.93	1.97	2.01	2.05	2.11	2.14	2.17	2.18
2.02	0.00	0.00	0.00	0.36	1.07	1.52	1.71	1.81	1.87	1.92	1.95	2.00	2.06	2.09	2.11	2.13
2.03	0.00	0.00	0.00	0.32	1.03	1.47	1.66	1.76	1.82	1.87	1.90	1.95	2.01	2.04	2.06	2.08
2.04	0.00	0.00	0.00	0.29	0.98	1.42	1.61	1.71	1.77	1.82	1.85	1.90	1.96	1.99	2.01	2.03
2.05	0.00	0.00	0.00	0.26	0.94	1.37	1.56	1.66	1.73	1.77	1.80	1.85	1.91	1.94	1.96	1.98
2.06	0.00	0.00	0.00	0.23	0.90	1.33	1.51	1.61	1.68	1.72	1.76	1.80	1.86	1.89	1.92	1.93
2.07	0.00	0.00	0.00	0.21	0.86	1.28	1.47	1.57	1.63	1.68	1.71	1.76	1.81	1.84	1.87	1.88
2.08	0.00	0.00	0.00	0.18	0.82	1.24	1.42	1.52	1.59	1.63	1.66	1.71	1.77	1.79	1.82	1.84
2.09	0.00	0.00	0.00	0.16	0.78	1.20	1.38	1.48	1.54	1.59	1.62	1.66	1.72	1.75	1.78	1.79
2.10	0.00	0.00	0.00	0.14	0.74	1.16	1.34	1.44	1.50	1.54	1.58	1.62	1.68	1.71	1.73	1.75
2.11	0.00	0.00	0.00	0.12	0.71	1.12	1.30	1.39	1.46	1.50	1.53	1.58	1.63	1.66	1.69	1.70
2.12	0.00	0.00	0.00	0.10	0.67	1.08	1.26	1.35	1.42	1.46	1.49	1.54	1.59	1.62	1.65	1.66
2.13	0.00	0.00	0.00	0.08	0.64	1.04	1.22	1.31	1.38	1.42	1.45	1.50	1.55	1.58	1.61	1.62
2.14	0.00	0.00	0.00	0.07	0.61	1.00	1.18	1.28	1.34	1.38	1.41	1.46	1.51	1.54	1.57	1.58
2.15	0.00	0.00	0.00	0.06	0.58	0.97	1.14	1.24	1.30	1.34	1.37	1.42	1.47	1.50	1.53	1.54
2.16	0.00	0.00	0.00	0.05	0.55	0.93	1.10	1.20	1.26	1.30	1.34	1.38	1.43	1.46	1.49	1.50
2.17	0.00	0.00	0.00	0.04	0.52	0.90	1.07	1.16	1.22	1.27	1.30	1.34	1.40	1.42	1.45	1.46
2.18	0.00	0.00	0.00	0.03	0.49	0.87	1.03	1.13	1.19	1.23	1.26	1.30	1.36	1.39	1.41	1.42
2.19	0.00	0.00	0.00	0.02	0.46	0.83	1.00	1.09	1.15	1.20	1.23	1.27	1.32	1.35	1.38	1.39
2.20	0.000	0.000	0.000	0.015	0.437	0.803	0.968	1.061	1.120	1.161	1.192	1.233	1.287	1.314	1.340	1.352
2.21	0.000	0.000	0.000	0.010	0.413	0.772	0.936	1.028	1.087	1.128	1.158	1.199	1.253	1.279	1.305	1.318
2.22	0.000	0.000	0.000	0.006	0.389	0.743	0.905	0.996	1.054	1.095	1.125	1.166	1.219	1.245	1.271	1.283
2.23	0.000	0.000	0.000	0.003	0.366	0.715	0.875	0.965	1.023	1.063	1.093	1.134	1.186	1.212	1.238	1.250
2.24	0.000	0.000	0.000	0.002	0.345	0.687	0.845	0.935	0.992	1.032	1.061	1.102	1.154	1.180	1.205	1.218
2.25	0.000	0.000	0.000	0.001	0.324	0.660	0.816	0.905	0.962	1.002	1.031	1.071	1.123	1.148	1.173	1.186
2.26	0.000	0.000	0.000	0.000	0.304	0.634	0.789	0.876	0.933	0.972	1.001	1.041	1.092	1.117	1.142	1.155
2.27	0.000	0.000	0.000	0.000	0.285	0.609	0.762	0.848	0.904	0.943	0.972	1.011	1.062	1.087	1.112	1.124
2.28	0.000	0.000	0.000	0.000	0.267	0.585	0.735	0.821	0.876	0.915	0.943	0.982	1.033	1.058	1.082	1.094
2.29	0.000	0.000	0.000	0.000	0.250	0.561	0.710	0.794	0.849	0.887	0.915	0.954	1.004	1.029	1.053	1.065

Q_U or Q_L	Sample Size 3	4	5	7	10	15	20	25	30	35	40	50	75	100	150	200
2.30	0.000	0.000	0.000	0.000	0.233	0.538	0.683	0.769	0.823	0.861	0.888	0.927	0.977	1.001	1.025	1.037
2.31	0.000	0.000	0.000	0.000	0.218	0.516	0.661	0.743	0.797	0.834	0.862	0.900	0.949	0.976	0.997	1.009
2.32	0.000	0.000	0.000	0.000	0.203	0.495	0.637	0.719	0.772	0.809	0.836	0.874	0.923	0.947	0.971	0.982
2.33	0.000	0.000	0.000	0.000	0.189	0.474	0.614	0.695	0.748	0.784	0.811	0.848	0.897	0.921	0.944	0.956
2.34	0.000	0.000	0.000	0.000	0.175	0.454	0.592	0.672	0.724	0.760	0.787	0.824	0.872	0.895	0.915	0.930
2.35	0.000	0.000	0.000	0.000	0.163	0.435	0.571	0.650	0.701	0.736	0.763	0.799	0.847	0.870	0.893	0.905
2.36	0.000	0.000	0.000	0.000	0.151	0.416	0.550	0.628	0.678	0.714	0.740	0.776	0.823	0.846	0.869	0.880
2.37	0.000	0.000	0.000	0.000	0.139	0.398	0.530	0.606	0.656	0.691	0.717	0.753	0.799	0.822	0.845	0.856
2.38	0.000	0.000	0.000	0.000	0.128	0.381	0.510	0.586	0.635	0.670	0.695	0.730	0.777	0.799	0.822	0.833
2.39	0.000	0.000	0.000	0.000	0.118	0.364	0.491	0.566	0.614	0.648	0.674	0.709	0.754	0.777	0.799	0.810
2.40	0.000	0.000	0.000	0.000	0.109	0.348	0.473	0.546	0.594	0.628	0.653	0.687	0.732	0.755	0.777	0.787
2.41	0.000	0.000	0.000	0.000	0.100	0.332	0.455	0.527	0.575	0.608	0.633	0.667	0.711	0.733	0.755	0.766
2.42	0.000	0.000	0.000	0.000	0.091	0.317	0.437	0.509	0.555	0.588	0.613	0.646	0.691	0.712	0.734	0.744
2.43	0.000	0.000	0.000	0.000	0.083	0.302	0.421	0.491	0.537	0.569	0.593	0.627	0.670	0.692	0.713	0.724
2.44	0.000	0.000	0.000	0.000	0.076	0.288	0.404	0.474	0.519	0.551	0.575	0.608	0.651	0.672	0.693	0.703
2.45	0.000	0.000	0.000	0.000	0.069	0.275	0.389	0.457	0.501	0.533	0.556	0.589	0.632	0.653	0.673	0.684
2.46	0.000	0.000	0.000	0.000	0.063	0.262	0.373	0.440	0.484	0.516	0.539	0.571	0.613	0.634	0.654	0.664
2.47	0.000	0.000	0.000	0.000	0.057	0.249	0.359	0.425	0.468	0.499	0.521	0.553	0.595	0.615	0.635	0.646
2.48	0.000	0.000	0.000	0.000	0.051	0.237	0.344	0.409	0.452	0.482	0.505	0.536	0.577	0.597	0.617	0.627
2.49	0.000	0.000	0.000	0.000	0.046	0.226	0.331	0.394	0.436	0.466	0.488	0.519	0.560	0.580	0.600	0.609
2.50	0.000	0.000	0.000	0.000	0.041	0.214	0.317	0.380	0.421	0.451	0.473	0.503	0.543	0.563	0.582	0.592
2.51	0.000	0.000	0.000	0.000	0.037	0.204	0.304	0.366	0.407	0.436	0.457	0.487	0.527	0.546	0.565	0.575
2.52	0.000	0.000	0.000	0.000	0.033	0.193	0.292	0.352	0.392	0.421	0.442	0.472	0.511	0.530	0.549	0.558
2.53	0.000	0.000	0.000	0.000	0.029	0.184	0.280	0.339	0.379	0.407	0.428	0.457	0.495	0.514	0.533	0.542
2.54	0.000	0.000	0.000	0.000	0.026	0.174	0.268	0.326	0.365	0.393	0.413	0.442	0.480	0.499	0.517	0.527
2.55	0.000	0.000	0.000	0.000	0.023	0.165	0.257	0.314	0.352	0.379	0.400	0.428	0.465	0.484	0.502	0.511
2.56	0.000	0.000	0.000	0.000	0.020	0.156	0.246	0.302	0.340	0.366	0.386	0.414	0.451	0.469	0.487	0.496
2.57	0.000	0.000	0.000	0.000	0.017	0.148	0.236	0.291	0.327	0.354	0.373	0.401	0.437	0.455	0.473	0.482
2.58	0.000	0.000	0.000	0.000	0.015	0.140	0.226	0.279	0.316	0.341	0.361	0.388	0.424	0.441	0.459	0.468
2.59	0.000	0.000	0.000	0.000	0.013	0.133	0.216	0.269	0.304	0.330	0.349	0.375	0.410	0.428	0.445	0.454
2.60	0.000	0.000	0.000	0.000	0.011	0.125	0.207	0.258	0.293	0.318	0.337	0.363	0.398	0.415	0.432	0.441
2.61	0.000	0.000	0.000	0.000	0.009	0.118	0.198	0.248	0.282	0.307	0.325	0.351	0.385	0.402	0.419	0.428
2.62	0.000	0.000	0.000	0.000	0.008	0.112	0.189	0.238	0.272	0.296	0.314	0.339	0.373	0.390	0.406	0.415
2.63	0.000	0.000	0.000	0.000	0.007	0.105	0.181	0.229	0.262	0.285	0.303	0.328	0.361	0.378	0.394	0.402
2.64	0.000	0.000	0.000	0.000	0.005	0.099	0.172	0.220	0.252	0.275	0.293	0.317	0.350	0.366	0.382	0.390
2.65	0.000	0.000	0.000	0.000	0.005	0.094	0.165	0.211	0.243	0.265	0.282	0.307	0.339	0.355	0.371	0.379
2.66	0.000	0.000	0.000	0.000	0.004	0.088	0.157	0.202	0.233	0.256	0.273	0.296	0.328	0.344	0.359	0.367
2.67	0.000	0.000	0.000	0.000	0.003	0.083	0.150	0.194	0.224	0.246	0.263	0.286	0.317	0.333	0.348	0.356
2.68	0.000	0.000	0.000	0.000	0.002	0.078	0.143	0.186	0.216	0.237	0.254	0.277	0.307	0.322	0.338	0.345
2.69	0.000	0.000	0.000	0.000	0.002	0.073	0.136	0.179	0.208	0.229	0.245	0.267	0.297	0.312	0.327	0.335

TABLE B-5--Continued

Table for Estimating the Lot Percent Defective Using Standard Deviation Method

Q_U or Q_L	Sample Size 3	4	5	7	10	15	20	25	30	35	40	50	75	100	150	200
2.70	0.000	0.000	0.000	0.000	0.001	0.068	0.130	0.171	0.200	0.220	0.236	0.258	0.288	0.302	0.317	0.325
2.71	0.000	0.000	0.000	0.000	0.001	0.064	0.124	0.166	0.192	0.212	0.227	0.249	0.278	0.293	0.307	0.315
2.72	0.000	0.000	0.000	0.000	0.000	0.060	0.118	0.157	0.184	0.204	0.219	0.241	0.269	0.283	0.298	0.305
2.73	0.000	0.000	0.000	0.000	0.000	0.057	0.112	0.151	0.177	0.197	0.211	0.232	0.260	0.274	0.288	0.296
2.74	0.000	0.000	0.000	0.000	0.000	0.053	0.107	0.144	0.170	0.189	0.204	0.224	0.252	0.266	0.279	0.286
2.75	0.000	0.000	0.000	0.000	0.000	0.049	0.102	0.138	0.163	0.182	0.196	0.216	0.243	0.257	0.271	0.277
2.76	0.000	0.000	0.000	0.000	0.000	0.046	0.097	0.132	0.157	0.175	0.189	0.209	0.235	0.249	0.262	0.269
2.77	0.000	0.000	0.000	0.000	0.000	0.043	0.092	0.126	0.151	0.168	0.182	0.201	0.227	0.241	0.254	0.260
2.78	0.000	0.000	0.000	0.000	0.000	0.040	0.087	0.121	0.145	0.162	0.175	0.194	0.220	0.233	0.246	0.252
2.79	0.000	0.000	0.000	0.000	0.000	0.037	0.083	0.115	0.139	0.156	0.169	0.187	0.212	0.225	0.238	0.244
2.80	0.000	0.000	0.000	0.000	0.000	0.035	0.079	0.110	0.133	0.150	0.162	0.181	0.205	0.218	0.230	0.237
2.81	0.000	0.000	0.000	0.000	0.000	0.032	0.075	0.105	0.128	0.144	0.156	0.174	0.198	0.211	0.223	0.229
2.82	0.000	0.000	0.000	0.000	0.000	0.030	0.071	0.101	0.122	0.138	0.150	0.168	0.192	0.204	0.216	0.222
2.83	0.000	0.000	0.000	0.000	0.000	0.028	0.067	0.096	0.117	0.133	0.145	0.162	0.185	0.197	0.209	0.215
2.84	0.000	0.000	0.000	0.000	0.000	0.026	0.064	0.092	0.112	0.128	0.139	0.156	0.179	0.190	0.202	0.208
2.85	0.000	0.000	0.000	0.000	0.000	0.024	0.060	0.088	0.108	0.122	0.134	0.150	0.173	0.184	0.195	0.201
2.86	0.000	0.000	0.000	0.000	0.000	0.022	0.057	0.084	0.103	0.118	0.129	0.145	0.167	0.178	0.189	0.195
2.87	0.000	0.000	0.000	0.000	0.000	0.020	0.054	0.080	0.099	0.113	0.124	0.139	0.161	0.172	0.183	0.188
2.88	0.000	0.000	0.000	0.000	0.000	0.019	0.051	0.076	0.094	0.108	0.119	0.134	0.155	0.166	0.177	0.182
2.89	0.000	0.000	0.000	0.000	0.000	0.017	0.048	0.073	0.090	0.104	0.114	0.129	0.150	0.160	0.171	0.176
2.90	0.000	0.000	0.000	0.000	0.000	0.016	0.046	0.069	0.087	0.100	0.110	0.125	0.145	0.155	0.165	0.171
2.91	0.000	0.000	0.000	0.000	0.000	0.015	0.043	0.066	0.083	0.096	0.106	0.120	0.140	0.150	0.160	0.165
2.92	0.000	0.000	0.000	0.000	0.000	0.013	0.041	0.063	0.079	0.092	0.101	0.115	0.135	0.145	0.155	0.160
2.93	0.000	0.000	0.000	0.000	0.000	0.012	0.038	0.060	0.076	0.088	0.097	0.111	0.130	0.140	0.149	0.154
2.94	0.000	0.000	0.000	0.000	0.000	0.011	0.036	0.057	0.072	0.084	0.093	0.107	0.125	0.135	0.144	0.149
2.95	0.000	0.000	0.000	0.000	0.000	0.010	0.034	0.054	0.069	0.081	0.090	0.103	0.121	0.130	0.140	0.144
2.96	0.000	0.000	0.000	0.000	0.000	0.009	0.032	0.051	0.066	0.077	0.086	0.099	0.117	0.126	0.135	0.140
2.97	0.000	0.000	0.000	0.000	0.000	0.009	0.030	0.049	0.063	0.074	0.083	0.095	0.112	0.121	0.130	0.135
2.98	0.000	0.000	0.000	0.000	0.000	0.008	0.028	0.046	0.060	0.071	0.079	0.091	0.108	0.117	0.126	0.130
2.99	0.000	0.000	0.000	0.000	0.000	0.007	0.027	0.044	0.057	0.068	0.076	0.088	0.104	0.113	0.122	0.126
3.00	0.000	0.000	0.000	0.000	0.000	0.006	0.025	0.042	0.055	0.065	0.073	0.084	0.101	0.109	0.118	0.122
3.01	0.000	0.000	0.000	0.000	0.000	0.006	0.024	0.040	0.052	0.062	0.070	0.081	0.097	0.105	0.114	0.118
3.02	0.000	0.000	0.000	0.000	0.000	0.005	0.022	0.038	0.050	0.059	0.067	0.078	0.093	0.101	0.110	0.114
3.03	0.000	0.000	0.000	0.000	0.000	0.005	0.021	0.036	0.048	0.057	0.064	0.075	0.090	0.098	0.106	0.110
3.04	0.000	0.000	0.000	0.000	0.000	0.004	0.019	0.034	0.045	0.054	0.061	0.072	0.087	0.094	0.102	0.106
3.05	0.000	0.000	0.000	0.000	0.000	0.004	0.018	0.032	0.043	0.052	0.059	0.069	0.083	0.091	0.099	0.103
3.06	0.000	0.000	0.000	0.000	0.000	0.003	0.017	0.030	0.041	0.050	0.056	0.066	0.080	0.088	0.095	0.099
3.07	0.000	0.000	0.000	0.000	0.000	0.003	0.016	0.029	0.039	0.047	0.054	0.064	0.077	0.085	0.092	0.096
3.08	0.000	0.000	0.000	0.000	0.000	0.003	0.015	0.027	0.037	0.045	0.052	0.061	0.074	0.081	0.089	0.092
3.09	0.000	0.000	0.000	0.000	0.000	0.002	0.014	0.026	0.036	0.043	0.049	0.059	0.072	0.078	0.086	0.089

Q_U or Q_L	Sample Size 3	4	5	7	10	15	20	25	30	35	40	50	75	100	150	200
3.10	0.000	0.000	0.000	0.000	0.000	0.002	0.013	0.024	0.034	0.041	0.047	0.056	0.069	0.076	0.083	0.086
3.11	0.000	0.000	0.000	0.000	0.000	0.002	0.012	0.023	0.032	0.039	0.045	0.054	0.066	0.073	0.080	0.083
3.12	0.000	0.000	0.000	0.000	0.000	0.002	0.011	0.022	0.031	0.038	0.043	0.052	0.064	0.070	0.077	0.080
3.13	0.000	0.000	0.000	0.000	0.000	0.002	0.011	0.021	0.029	0.036	0.041	0.050	0.061	0.068	0.074	0.077
3.14	0.000	0.000	0.000	0.000	0.000	0.001	0.010	0.019	0.028	0.034	0.040	0.048	0.059	0.065	0.071	0.075
3.15	0.000	0.000	0.000	0.000	0.000	0.001	0.009	0.018	0.026	0.033	0.038	0.046	0.057	0.063	0.069	0.072
3.16	0.000	0.000	0.000	0.000	0.000	0.001	0.009	0.017	0.025	0.031	0.036	0.044	0.055	0.060	0.066	0.069
3.17	0.000	0.000	0.000	0.000	0.000	0.001	0.008	0.016	0.024	0.030	0.035	0.042	0.053	0.058	0.064	0.067
3.18	0.000	0.000	0.000	0.000	0.000	0.001	0.007	0.015	0.022	0.028	0.033	0.040	0.050	0.056	0.062	0.065
3.19	0.000	0.000	0.000	0.000	0.000	0.001	0.007	0.015	0.021	0.027	0.032	0.038	0.049	0.054	0.059	0.062
3.20	0.000	0.000	0.000	0.000	0.000	0.001	0.006	0.014	0.020	0.026	0.030	0.037	0.047	0.052	0.057	0.060
3.21	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.013	0.019	0.024	0.029	0.035	0.045	0.050	0.055	0.058
3.22	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.012	0.018	0.023	0.027	0.034	0.043	0.048	0.053	0.056
3.23	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.011	0.017	0.022	0.026	0.032	0.041	0.046	0.051	0.054
3.24	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.011	0.016	0.021	0.025	0.031	0.040	0.044	0.049	0.052
3.25	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.010	0.015	0.020	0.024	0.030	0.038	0.043	0.048	0.050
3.26	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.009	0.015	0.019	0.023	0.028	0.037	0.041	0.046	0.048
3.27	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.009	0.014	0.019	0.022	0.027	0.035	0.040	0.044	0.046
3.28	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.008	0.013	0.017	0.021	0.026	0.034	0.038	0.042	0.045
3.29	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.008	0.012	0.016	0.020	0.025	0.032	0.037	0.041	0.043
3.30	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.007	0.012	0.015	0.019	0.024	0.031	0.035	0.039	0.042
3.31	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.007	0.011	0.015	0.018	0.023	0.030	0.034	0.038	0.040
3.32	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.006	0.010	0.014	0.017	0.022	0.029	0.032	0.036	0.039
3.33	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.006	0.010	0.013	0.016	0.021	0.027	0.031	0.035	0.037
3.34	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.006	0.009	0.013	0.015	0.020	0.026	0.030	0.034	0.036
3.35	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.005	0.009	0.012	0.015	0.019	0.025	0.029	0.032	0.034
3.36	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.005	0.008	0.011	0.014	0.018	0.024	0.028	0.031	0.033
3.37	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.005	0.008	0.011	0.013	0.017	0.023	0.026	0.030	0.032
3.38	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.004	0.007	0.010	0.013	0.016	0.022	0.025	0.029	0.031
3.39	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.004	0.007	0.010	0.012	0.016	0.021	0.024	0.028	0.029
3.40	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.004	0.007	0.009	0.011	0.015	0.020	0.023	0.027	0.028
3.41	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.006	0.009	0.011	0.014	0.020	0.022	0.026	0.027
3.42	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.006	0.008	0.010	0.014	0.019	0.022	0.025	0.026
3.43	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.005	0.008	0.010	0.013	0.018	0.021	0.024	0.025
3.44	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.005	0.007	0.009	0.012	0.017	0.020	0.023	0.024
3.45	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.005	0.007	0.009	0.012	0.016	0.019	0.022	0.023
3.46	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.005	0.007	0.008	0.011	0.016	0.018	0.021	0.022
3.47	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.004	0.006	0.008	0.011	0.015	0.017	0.020	0.022
3.48	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.004	0.006	0.007	0.010	0.014	0.017	0.019	0.021
3.49	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.005	0.007	0.010	0.014	0.016	0.019	0.020

TABLE B-5—Continued

Table for Estimating the Lot Percent Defective Using Standard Deviation Method

Q_U or Q_L	Sample Size															
	3	4	5	7	10	15	20	25	30	35	40	50	75	100	150	200
3.50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.003	0.005	0.007	0.009	0.013	0.015	0.018	0.019
3.51	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.003	0.005	0.006	0.009	0.013	0.015	0.017	0.018
3.52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.003	0.005	0.006	0.008	0.012	0.014	0.017	0.018
3.53	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.004	0.006	0.008	0.012	0.014	0.016	0.017
3.54	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.004	0.005	0.008	0.011	0.013	0.015	0.016
3.55	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.004	0.005	0.007	0.011	0.012	0.015	0.016
3.56	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.004	0.005	0.007	0.010	0.012	0.014	0.015
3.57	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.005	0.006	0.010	0.011	0.013	0.014
3.58	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.006	0.009	0.011	0.013	0.014
3.59	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.006	0.009	0.010	0.012	0.013
3.60	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.006	0.008	0.010	0.012	0.013
3.61	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.005	0.008	0.010	0.011	0.012
3.62	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.003	0.005	0.008	0.009	0.011	0.012
3.63	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.005	0.007	0.009	0.010	0.011
3.64	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.004	0.007	0.008	0.010	0.011
3.65	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.004	0.007	0.008	0.010	0.010
3.66	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.006	0.008	0.009	0.010
3.67	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.006	0.007	0.009	0.010
3.68	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.002	0.004	0.006	0.007	0.008	0.009
3.69	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.002	0.003	0.005	0.007	0.008	0.009

Q_U or Q_L	Sample Size															
	3	4	5	7	10	15	20	25	30	35	40	50	75	100	150	200
3.70	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.002	0.003	0.005	0.006	0.008	0.008
3.71	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.005	0.006	0.007	0.008
3.72	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.005	0.006	0.007	0.008
3.73	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.005	0.006	0.007	0.007
3.74	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.004	0.005	0.007	0.007
3.75	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.002	0.004	0.005	0.006	0.007
3.76	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.004	0.005	0.006	0.007
3.77	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.004	0.005	0.006	0.006
3.78	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.004	0.004	0.005	0.006
3.79	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.004	0.005	0.006
3.80	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.004	0.005	0.006
3.81	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.004	0.005	0.005
3.82	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.004	0.005	0.005
3.83	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.004	0.004	0.005
3.84	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.003	0.003	0.004	0.005
3.85	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.003	0.004	0.004
3.86	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.004	0.004
3.87	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.004	0.004
3.88	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.004	0.004
3.89	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.003	0.004
3.90	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.003	0.004

Part III

ESTIMATION OF PROCESS AVERAGE AND CRITERIA FOR REDUCED AND TIGHTENED INSPECTION

B13. ESTIMATION OF PROCESS AVERAGE

The average percent defective, based upon a group of lots submitted for original inspection, is called the process average. Original inspection is the first inspection of a particular quantity of product submitted for acceptability as distinguished from the inspection of product which has been resubmitted after prior rejection. The process average shall be estimated from the results of inspection of samples drawn from a specified number of preceding lots for the purpose of determining severity of inspection during the course of a contract in accordance with paragraph B14.3. Any lot shall be included only once in estimating the process average. The estimate of the process average is designated by $\bar{p}_U$ when computed with respect to an upper specification limit, by $\bar{p}_L$ when computed with respect to a lower specification limit, and by $\bar{p}$ when computed with respect to a double specification limit.

B13.1 Abnormal Results. The results of inspection of product manufactured under conditions not typical of usual production shall be excluded from the estimated process average.

B13.2 Computation of the Estimated Process Average. The estimated process average is the arithmetic mean of the estimated lot percent defectives computed from the sampling inspection results of the preceding ten (10) lots or as may be otherwise designated. In order to estimate the lot percent defective, the quality indices Q_U and/or Q_L shall be computed for each lot. These are: $Q_U = (U-\bar{X})/s$ and $Q_L = (\bar{X}-L)/s$. (See paragraph B11.2.)

B13.2.1 Single Specification Limit.[6] The estimated lot percent defective shall be determined from Table B-5 for the plans based on the standard deviation method. The quality index Q_U shall be used for the case of an upper specification limit or Q_L for the case of a lower specification limit. Table B-5 is entered with Q_U or Q_L and the sample size, and the corresponding estimated lot percent defective p_U or p_L, respectively, is read from the table. The estimated process average $\bar{p}_U$ is the arithmetic mean of the individual estimated lot percent defectives p_U's. Similarly, the estimated process average $\bar{p}_L$ is the arithmetic mean of the individual estimated lot percent defectives p_L's.

B13.2.2 Double Specification Limit. The estimated lot percent defective shall be determined from Table B-5 for the plans based on the standard deviation method. The quality indices Q_U and Q_L shall be computed. Table B-5 is entered separately with Q_U and Q_L and the sample size, and the corresponding p_U and p_L are read from the table. The estimated lot percent defective is $p = p_U + p_L$. The estimated process average $\bar{p}$ is the arithmetic mean of the individual estimated lot percent defectives p's.

B13.2.3 Special Case. If the quality index Q_U or Q_L is a negative number, then Table B-5 is entered by disregarding the negative sign. However, in this case the estimated lot percent defective above the upper limit or below the lower limit is obtained by subtracting the percentage found in the table from 100%.[7]

B14. NORMAL, TIGHTENED, AND REDUCED INSPECTION

This Standard established sampling plans for normal, tightened, and reduced inspection.

B14.1 At Start of Inspection. Normal inspection shall be used at the start of inspection unless otherwise designated.

B14.2 During Inspection. During the course of inspection, normal inspection shall be used when inspection conditions are such that tightened or reduced inspection is not required in accordance with paragraphs B14.3 and B14.4.

B14.3 Tightened Inspection. Tightened inspection shall be instituted when the estimated process average computed from the

[6]When Form 1--Single Specification Limit is used for the acceptability criterion, the estimate of lot percent defective p_U or p_L is not obtained; in order to estimate the process average, it is necessary to complete paragraphs B6.2 and B6.3 of Form 2.

[7]For example, if $Q_U = -.50$ and $Q_L = 1.60$, using sample size 50, p_U = 100% - 30.93% = 69.07%, p_L = 5.33% and p = 69.07% + 5.33% = 74.40%.

preceding ten (10) lots (or such other number of lots designated) in accordance with paragraph B13.2 is greater than the AQL, and when more than a certain number T of these lots have estimates of the percent defective exceeding the AQL. The T values are given in Table B-6 for the process average computed from 5, 10, or 15 lots.[8] Normal inspection shall be reinstated if the estimated process average of lots under tightened inspection is equal to or less than the AQL.

B14.4 Reduced Inspection. Reduced inspection may be instituted provided that all of the following conditions are satisfied:

Condition A. The preceding ten (10) lots (or such other number of lots designated) have been under normal inspection and none has been rejected.

Condition B. The estimated percent defective for each of these preceding lots is less than the applicable lower limit shown in Table B-7; or for certain sampling plans, the estimated lot percent defective is equal to zero for a specified number of consecutive lots (see Table B-7).

Condition C. Production is at a steady rate.

Normal inspection shall be reinstated if any one of the following conditions occurs under reduced inspection.

Condition D. A lot is rejected.

Condition E. The estimated process average is greater than the AQL.

Condition F. Production becomes irregular or delayed.

Condition G. Other conditions as may warrant that normal inspection should be reinstated.

B14.5 Sampling Plans for Tightened or Reduced Inspection. Sampling plans for tightened and reduced inspection are provided in Section B, Parts I and II.

[8] If the sample size code letter is not the same for all samples used, the entry in Table B-6 is determined by the sample size code letter corresponding to the smallest sample size used in any of the lots included in the estimation of the process average.

TABLE B-6

Standard Deviation Method

Values of T for Tightened Inspection

Sample size code letter	Acceptable Quality Levels (in percent defective)														Number of Lots
	.04	.065	.10	.15	.25	.40	.65	1.0	1.5	2.5	4.0	6.5	10.0	15.0	
B	*	*	*	*	*	*	*	*	*	2 4 5	3 5 6	4 6 8	4 7 9	4 8 11	5 10 15
C	*	*	*	*	*	*	*	2 3 5	2 4 6	3 5 7	3 6 8	4 7 9	4 7 10	4 8 11	5 10 15
D	*	*	*	*	*	*	2 4 5	3 4 6	3 5 7	3 6 8	4 6 9	4 7 10	4 7 10	4 8 11	5 10 15
E	*	*	*	*	2 4 5	3 4 6	3 5 6	3 5 7	4 6 8	4 6 9	4 7 9	4 7 10	4 8 11	4 8 11	5 10 15
F	*	*	*	3 4 6	3 5 6	3 5 7	3 6 8	4 6 8	4 6 9	4 7 9	4 7 10	4 8 11	4 8 11	4 8 11	5 10 15
G	3 4 6	3 5 6	3 5 6	3 5 7	3 6 7	4 6 8	4 6 9	4 7 9	4 7 9	4 7 10	4 7 10	4 8 11	4 8 11	4 8 11	5 10 15
H	3 5 6	3 5 7	3 5 7	3 6 8	4 6 8	4 6 9	4 7 9	4 7 9	4 7 10	4 7 10	4 8 11	4 8 11	4 8 11	4 8 11	5 10 15
I	3 5 7	3 6 7	4 6 8	4 6 8	4 6 9	4 7 9	4 7 9	4 7 10	4 7 10	4 7 10	4 8 11	4 8 11	4 8 11	4 8 11	5 10 15
J	3 6 8	4 6 8	4 6 8	4 6 9	4 7 9	4 7 9	4 7 10	4 7 10	4 7 10	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	5 10 15
K	4 6 8	4 6 8	4 6 9	4 6 9	4 7 9	4 7 9	4 7 10	4 7 10	4 8 10	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	5 10 15
L	4 6 8	4 6 9	4 6 9	4 7 9	4 7 9	4 7 10	4 7 10	4 7 10	4 8 10	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	5 10 15
M	4 6 9	4 7 9	4 7 9	4 7 9	4 7 10	4 7 10	4 7 10	4 7 10	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	5 10 15
N	4 7 9	4 7 9	4 7 10	4 7 10	4 7 10	4 7 10	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	5 10 15
O	4 7 10	4 7 10	4 7 10	4 7 10	4 7 10	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	5 10 15

*There are no sampling plans provided in this Standard for these code letters and AQL values.

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TABLE B-6—Continued Standard Deviation Method

Values of T for Tightened Inspection

Sample size code letter	Acceptable Quality Levels (in percent defective)														Number of Lots
	.04	.065	.10	.15	.25	.40	.65	1.0	1.5	2.5	4.0	6.5	10.0	15.0	
P	4 7 10	4 7 10	4 7 10	4 8 10	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 12	5 10 15
Q	4 7 10	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 12	5 10 15

The top figure in each block refers to the preceding 5 lots, the middle figure to the preceding 10 lots and the bottom figure to the preceding 15 lots.

Tightened inspection is required when the number of lots with estimates of percent defective above the AQL from the preceding 5, 10, or 15 lots is greater than the given value of T in the table, and the process average from these lots exceeds the AQL.

All estimates of the lot percent defective are obtained from Table B-5.

TABLE B-7

Standard Deviation Method

Limits of Estimated Lot Percent Defective for Reduced Inspection

Sample size code letter	Acceptable Quality Levels .04	.065	.10	.15	.25	.40	.65	1.0	1.5	2.5	4.0	6.5	10.0	15.0	Number of Lots
B	*	*	*	*	*	*	*	*	*	[42]**	[28]**	[18]**	[12]**	[9]**	
C	*	*	*	*	*	*	*	[45]**	[31]**	[22]**	[15]**	[10]**	[7]**	.77 15.00 ▲	5 10 15
D	*	*	*	*	*	*	[33]**	[25]**	[18]**	[13]**	[9]**	0.00 4.40 6.50	.74 9.96 10.00	6.06 15.00 ▲	5 10 15
E	*	*	*	*	[25]**	[18]**	[14]**	[11]**	.00 .10 .88	.00 .88 2.49	.13 2.65 4.00	1.38 5.96 6.50	4.24 10.00 ▲	9.09 15.00 ▲	5 10 15
F	*	*	*	▼ .000 .002	.000 .001 .029	.000 .016 .123	.000 .101 .369	.003 .317 .81	.044 .74 1.50	.306 1.80 2.50	1.05 3.56 4.00	2.81 6.50 ▲	5.79 10.00 ▲	10.47 15.00 ▲	5 10 15
G	▼ .000 .003	.000 .002 .010	.000 .006 .028	.000 .018 .062	.002 .057 .151	.011 .143 .315	.047 .330 .626	.136 .643 1.00	.323 1.14 1.50	.84 2.23 2.50	1.84 3.94 4.00	3.80 6.50 ▲	6.86 10.00 ▲	11.52 15.00 ▲	5 10 15
H	.000 .004 .013	.000 .010 .029	.002 .023 .058	.005 .048 .105	.017 .111 .215	.048 .225 .396	.123 .445 .65	.266 .785 1.00	.521 1.31 1.50	1.14 2.40 2.50	2.24 4.00 ▲	4.29 6.50 ▲	7.40 10.00 ▲	12.07 15.00 ▲	5 10 15
I	.001 .009 .021	.002 .020 .043	.006 .039 .077	.014 .071 .133	.037 .146 .248	.083 .274 .40	.185 .509 .65	.360 .863 1.00	.653 1.39 1.50	1.33 2.48 2.50	2.49 4.00 ▲	4.59 6.50 ▲	7.74 10.00 ▲	12.43 15.00 ▲	5 10 15
J	.002 .013 .027	.005 .027 .052	.012 .050 .089	.023 .087 .146	.054 .169 .25	.113 .306 .40	.233 .550 .65	.431 .909 1.00	.750 1.44 1.50	1 47 2.50 ▲	2.66 4.00 ▲	4.81 6.50 ▲	7.98 10.00 ▲	12.69 15.00 ▲	5 10 15

*There are no sampling plans provided in this Standard for these code letters and AQL values.

TABLE B-7—Continued

Standard Deviation Method

Limits of Estimated Lot Percent Defective for Reduced Inspection

Sample size code letter	Acceptable Quality Levels														Number of Lots
	.04	.065	.10	.15	.25	.40	.65	1.0	1.5	2.5	4.0	6.5	10.0	15.0	
K	.004	.008	.017	.032	.069	.137	.270	.483	.821	1.57	2.79	4.96	8.15	12.88	5
	.017	.033	.059	.099	.186	.328	.577	.940	1.47	2.50	4.00	6.50	10.00	15.00	10
	.032	.058	.097	.15	.25	.40	.65	1.00	1.50	▲	▲	▲	▲	▲	15
L	.005	.011	.022	.040	.082	.157	.300	.525	.876	1.64	2.88	5.08	8.29	13.03	5
	.020	.038	.065	.108	.199	.343	.596	.961	1.49	2.50	4.00	6.50	10.00	15.00	10
	.035	.063	.10	.15	.25	.40	.65	1.00	1.50	▲	▲	▲	▲	▲	15
M	.008	.016	.030	.052	.102	.187	.345	.587	.959	1.76	3.03	5.27	8.50	13.25	5
	.025	.045	.075	.120	.215	.364	.621	.989	1.50	2.50	4.00	6.50	10.00	15.00	10
	.04	.065	.10	.15	.25	.40	.65	1.00	▲	▲	▲	▲	▲	▲	15
N	.014	.026	.044	.072	.134	.235	.414	.681	1.082	1.92	3.24	5.52	8.81	13.60	5
	.031	.054	.087	.136	.236	.389	.65	1.00	1.50	2.50	4.00	6.50	10.00	15.00	10
	.04	.065	.10	.15	.25	.40	▲	▲	▲	▲	▲	▲	▲	▲	15
O	.018	.032	.053	.085	.153	.261	.453	.733	1.149	2.01	3.36	5.67	8.98	13.80	5
	.034	.058	.093	.143	.245	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00	15.00	10
	.04	.065	.10	.15	.25	▲	▲	▲	▲	▲	▲	▲	▲	▲	15
P	.023	.039	.064	.101	.177	.296	.501	.799	1.237	2.13	3.52	5.87	9.22	14.07	5
	.038	.064	.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00	15.00	10
	.04	.065	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	15
Q	.025	.044	.069	.108	.188	.312	.525	.830	1.276	2.19	3.59	5.96	9.32	14.19	5
	.04	.065	.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00	15.00	10
	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	15

All AQL and table values, except those in the brackets, are in percent defective.

▼▲Use the first figure in direction of arrow and corresponding number of lots. In each block the top figure refers to the preceding 5 lots, the middle figure to the preceding 10 lots, and the bottom figure to the preceding 15 lots.

Reduced inspection may be instituted when every estimated lot percent defective from the preceding 5, 10, or 15 lots is below the figure given in the table; reduced inspection for sampling plans marked (**) in the table requires that the estimated lot percent defective is equal to zero for the number of consecutive lots indicated in brackets. In addition, all other conditions for reduced inspection, in Part III of Section B, must be satisfied.

All estimates of the lot percent defective are obtained from Table B-5.

TABLE B-8

Values of F for Maximum Standard Deviation (MSD)

Sample size code letter	Sample size	Acceptable Quality Levels (in percent defective)													
		.04	.065	.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00	15.00
B	3										.436	.453	.475	.502	.538
C	4								.339	.353	.374	.399	.432	.472	.528
D	5							.294	.308	.323	.346	.372	.408	.452	.511
E	7					.242	.253	.266	.280	.295	.318	.345	.381	.425	.485
F	10				.214	.224	.235	.248	.261	.276	.298	.324	.359	.403	.460
G	15	.182	.188	.195	.202	.211	.222	.235	.248	.262	.284	.309	.344	.386	.442
H	20	.177	.183	.190	.197	.206	.216	.229	.242	.255	.277	.302	.336	.377	.432
I	25	.174	.180	.187	.193	.203	.212	.225	.238	.251	.273	.297	.331	.372	.426
J	30	.173	.179	.185	.192	.201	.210	.223	.236	.249	.270	.295	.328	.369	.423
K	35	.170	.176	.183	.189	.198	.208	.220	.232	.245	.266	.291	.323	.364	.416
L	40	.169	.176	.182	.188	.198	.207	.219	.232	.245	.266	.290	.323	.363	.416
M	50	.166	.172	.178	.184	.194	.203	.214	.227	.241	.261	.284	.317	.356	.408
N	75	.162	.168	.174	.181	.189	.199	.211	.223	.235	.255	.279	.310	.348	.399
O	100	.160	.166	.172	.179	.187	.197	.208	.220	.233	.253	.276	.307	.345	.395
P	150	.158	.163	.170	.175	.185	.193	.206	.216	.230	.249	.271	.302	.341	.388
Q	200	.157	.163	.168	.175	.183	.193	.203	.215	.228	.248	.269	.302	.338	.386

The MSD may be obtained by multiplying the factor **F** by the difference between the upper specification limit U and lower specification limit L. The formula is *MSD = F(U-L)*. The *MSD* serves as a guide for the magnitude of the estimate of lot standard deviation when using plans for the double specification limit case, based on the estimate of lot standard deviation of unknown variability. The estimate of lot standard deviation, if it is less than the MSD, helps to insure, but does not guarantee, lot acceptability.

NOTE: There is a corresponding acceptability constant in Table B-1 for each value of **F**. For reduced inspection, find the acceptability constant of Table B-2 in Table B-1 and use the corresponding value of **F**.

APPENDIX B

Definitions

Symbol	Read	Definition
n		Sample size for a single lot.
$\bar{X}$	X bar	Sample mean. Arithmetic mean of sample measurements from a single lot.
s		Estimate of lot standard deviation. Standard deviation of sample measurements from a single lot. (See Examples in Section B.)
U		Upper specification limit.
L		Lower specification limit.
k		The acceptability constant given in Tables B-1 and B-2.
Q_U	Q sub U	Quality index for use with Table B-5.
Q_L	Q sub L	Quality index for use with Table B-5.
p_U	p sub U	Sample estimate of the lot percent defective above U from Table B-5.
p_L	p sub L	Sample estimate of the lot percent defective below L from Table B-5.
p		Total sample estimate of the lot percent defective $p = p_U + p_L$.
M		Maximum allowable percent defective for sample estimates given in Tables B-3 and B-4.
M_U	M sub U	Maximum allowable percent defective above U given in Tables B-3 and B-4. (For use when different AQL values for U and L are specified.)
M_L	M sub L	Maximum allowable percent defective below L given in Tables B-3 and B-4. (For use when different AQL values for U and L are specified.)
$\bar{p}$	p bar	Sample estimate of the process percent defective, i.e., the estimated process average.
$\bar{p}_U$	p bar sub U	The estimated process average for an upper specification limit.
$\bar{p}_L$	p bar sub L	The estimated process average for a lower specification limit.
T		The maximum number of estimated process averages which may exceed the AQL given in Table B-6. (For use in determining application of tightened inspection.)
F		A factor used in determining the Maximum Standard Deviation (MSD). The F values are given in Table B-8.
$>$	Greater than	Greater than
$<$	Less than	Less than
Σ	Sum of	Sum of

SECTION C

VARIABILITY UNKNOWN—RANGE METHOD

Part I

SINGLE SPECIFICATION LIMIT

C1. SAMPLING PLAN FOR SINGLE SPECIFICATION LIMIT

This part of the Standard describes the procedures for use with plans for a single specification limit when variability of the lot with respect to the quality characteristic is unknown and the range method is used. The acceptability criterion is given in two equivalent forms. These are identified as Form 1 and Form 2.

C1.1 Use of Sampling Plans. To determine whether the lot meets the acceptability criterion with respect to a particular quality characteristic and AQL value, the applicable sampling plan shall be used in accordance with the provisions of Section A, General Description of Sampling Plans, and those in this part of the Standard.

C1.2 Drawing of Samples. All samples shall be drawn in accordance with paragraph A7.2.

C1.3 Determination of Sample Size Code Letter. The sample size code letter shall be selected from Table A-2 in accordance with paragraph A7.1.

C2. SELECTING THE SAMPLING PLAN WHEN FORM 1 IS USED

C2.1 Master Sampling Tables. The master sampling tables for plans based on variability unknown for a single specification limit when using the range method are Tables C-1 and C-2. Table C-1 is used for normal and tightened inspection and Table C-2 for reduced inspection.

C2.2 Obtaining the Sampling Plan. The sampling plan consists of a sample size and an associated acceptability constant.[1] The sampling plan is obtained from Master Table C-1 or C-2.

C2.2.1 Sample Size. The sample size n is shown in the master table corresponding to each sample size code letter.

C2.2.2 Acceptability Constant. The acceptability constant k, corresponding to the sample size mentioned in paragraph C2.2.1, is indicated in the column of the master table corresponding to the applicable AQL value. Table C-1 is entered from the top for normal inspection and from the bottom for tightened inspection. Sampling plans for reduced inspection are provided in Table C-2.

C3. LOT-BY-LOT ACCEPTABILITY PROCEDURES WHEN FORM 1 IS USED[2]

C3.1 Acceptability Criterion. The degree of conformance of a quality characteristic with respect to a single specification limit shall be judged by the quantity $(U-\bar{X})/\bar{R}$ or $(\bar{X}-L)/\bar{R}$.

C3.2 Computation. The following quantity shall be computed: $(U-\bar{X})/\bar{R}$ or $(\bar{X}-L)/\bar{R}$, depending on whether the specification limit is an upper or a lower limit, where

U is the upper specification limit,
L is the lower specification limit,
$\bar{X}$ is the sample mean, and
$\bar{R}$ is the average range of the sample.

In this Standard, $\bar{R}$ is the average range of subgroup ranges. Each of the subgroups consists of 5 measurements, except for those plans with sample size 3, 4, or 7 in which case the subgroup size is the same as the sample size. In computing $\bar{R}$, the order of the sample measurements as made must be retained. Subgroups of consecutive measurements must be formed and the range of each subgroup obtained. $\bar{R}$ is the average of the individual subgroup ranges.

C3.3 Acceptability Criterion. Compare the quantity $(U-\bar{X})/\bar{R}$ or $(\bar{X}-L)/\bar{R}$ with the acceptability constant k. If $(U-\bar{X})/\bar{R}$ or $(\bar{X}-L)/\bar{R}$ is equal to or greater than k, the lot meets the acceptability criterion; if $(U-\bar{X})/\bar{R}$ or $(\bar{X}-L)/\bar{R}$ is less than k or negative, then the lot does not meet the acceptability criterion.

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[1] See Appendix C for definitions of all symbols used in the sampling plans based on variability unknown-range method.

[2] See Example C-1 for a complete example of this procedure.

C4. SUMMARY FOR OPERATION OF SAMPLING PLAN WHEN FORM 1 IS USED

The following steps summarize the procedures to be followed:

(1) Determine the sample size code letter from Table A-2 by using the lot size and the inspection level.

(2) Obtain plan from Master Table C-1 or C-2 by selecting the sample size n and the acceptability constant k.

(3) Select at random the sample of n units from the lot; inspect and record the measurement of the quality characteristic for each unit of the sample.

(4) Compute the sample mean $\bar{X}$ and the average range of the sample $\bar{R}$, and also compute the quantity $(U-\bar{X})/\bar{R}$ for an upper specification limit U or the quantity $(\bar{X}-L)/\bar{R}$ for a lower specification limit L.

(5) If the quantity $(U-\bar{X})/\bar{R}$ or $(\bar{X}-L)/\bar{R}$ is equal to or greater than k, the lot meets the acceptability criterion; if $(U-\bar{X})/\bar{R}$ or $(\bar{X}-L)/\bar{R}$ is less than k or negative, then the lot does not meet the acceptability criterion.

C5. SELECTING THE SAMPLING PLAN WHEN FORM 2 IS USED

C5.1 Master Sampling Tables. The master sampling tables for plans based on variability unknown for a single specification limit when using the range method are Tables C-3 and C-4 of Part II. Table C-3 is used for normal and tightened inspection and Table C-4 for reduced inspection.

C5.2 Obtaining the Sampling Plan. The sampling plan consists of a sample size and an associated maximum allowable percent defective. The sampling plan is obtained from Master Table C-3 or C-4.

C5.2.1 *Sample Size*. The sample size n is shown in the master table corresponding to each sample size code letter.

C5.2.2 Maximum Allowable Percent Defective. The maximum allowable percent defective M for sample estimates corresponding to the sample size mentioned in paragraph C5.2.1 is indicated in the column of the master table corresponding to the applicable AQL value. Table C-3 is entered from the top for normal inspection and from the bottom for tightened inspection. Sampling plans for reduced inspection are provided in Table C-4.

C6. LOT-BY-LOT ACCEPTABILITY PROCEDURES WHEN FORM 2 IS USED[3]

C6.1 Acceptability Criterion. The degree of conformance of a quality characteristic with respect to a single specification limit shall be judged by the percent of nonconforming product outside the upper or lower specification limit. The percentage of nonconforming product is estimated by entering Table C-5 with the quality index and the sample size.

C6.2 Computation of Quality Index. The quality index $Q_U = (U-\bar{X})c/\bar{R}$ shall be computed if the specification limit is an upper limit U, or $Q_L = (\bar{X}-L)c/\bar{R}$ if it is a lower limit L. The quantities, $\bar{X}$ and $\bar{R}$, are the sample mean and average range of the sample, respectively. The computation of $\bar{R}$ is explained in paragraph C3.2. The factor c is provided in Master Tables C-3 and C-4 corresponding to the sample size code letter.

C6.3 Estimate of Percent Defective in Lot. The quality of a lot shall be expressed by p_U, the estimated percent defective in the lot above the upper specification limit, or by p_L, the estimated percent defective below the lower specification limit. The estimated percent defective p_U or p_L is obtained by entering Table C-5 with Q_U or Q_L and the appropriate sample size.

C6.4 Acceptability Criterion. Compare the estimated lot percent defective p_U or p_L with the maximum allowable percent defective M. If p_U or p_L is equal to or less than M, the lot meets the acceptability criterion; if p_U or p_L is greater than M or if Q_U or Q_L is negative, then the lot does not meet the acceptability criterion.

C7. SUMMARY OF OPERATION OF SAMPLING PLAN WHEN FORM 2 IS USED

The following steps summarize the procedures to be followed:

(1) Determine the sample size code letter from Table A-2 by using the lot size and the inspection level.

(2) Obtain plan from Master Table C-3 or C-4 by selecting the sample size n, the factor c, and the maximum allowable percent defective M.

(3) Select at random the sample of n units from the lot; inspect and record the measurement of the quality characteristic on each unit of the sample.

[3]See Example C-2 for a complete example of this procedure.

(4) Compute the sample mean $\bar{X}$ and the average range of the sample $\bar{R}$.

(5) Compute the quality index $Q_U = (U-\bar{X})c/\bar{R}$ if the upper specification limit U is specified, or $Q_L = (\bar{X}-L)c/\bar{R}$ if the lower specification limit L is specified.

(6) Determine the estimated lot percent defective p_U or p_L from Table C-5.

(7) If the estimated lot percent defective p_U or p_L is equal to or less than the maximum allowable percent defective M, the lot meets the acceptability criterion; if p_U or p_L is greater than M or if Q_U or Q_L is negative, then the lot does not meet the acceptability criterion.

EXAMPLE C-1

Example of Calculations

Single Specification Limit—Form 1

Variability Unknown - Range Method

Example The lower specification limit for electrical resistance of a certain electrical component is 620 ohms. A lot of 100 items is submitted for inspection. Inspection Level IV, normal inspection, with AQL = .4% is to be used. From Tables A-2 and C-1 it is seen that a sample of size 10 is required. Suppose that values of the sample resistances in the order reading from left to right are as follows:

643, 651, 619, 627, 658, (R_1 = 658 - 619 = 39)
670, 673, 641, 638, 650, (R_2 = 673 - 638 = 35)

and compliance with the acceptability criterion is to be determined.

Line	Information Needed	Value Obtained	Explanation
1	Sample Size: n	10	
2	Sum of Measurements: ΣX	6470	
3	Sample Mean $\bar{X}$: $\Sigma X/n$	647	6470/10
4	Average Range $\bar{R}$: ΣR/no. of subgroups	37	(39+35)/2
5	Specification Limit (Lower): L	620	
6	The quantity: $(\bar{X}-L)/\bar{R}$	.730	(647-620)/37
7	Acceptability Constant: k	.811	See Table C-1
8	Acceptability Criterion: Compare $(\bar{X}-L)/\bar{R}$ with k	.730 < .811	See Para. C3.3

The lot does not meet the acceptability criterion, since $(X-L)/\bar{R}$ is less than k.

NOTE: If a single upper specification limit U is given, then compute the quantity $(U-\bar{X})/\bar{R}$ in line 6 and compare it with k; the lot meets the acceptability criterion, if $(U-\bar{X})/\bar{R}$ is equal to or greater than k.

EXAMPLE C-2

Example of Calculations

Single Specification Limit—Form 2

Variability Unknown - Range Method

Example A lower specification limit for electrical resistance of a certain electrical component is 620 ohms. A lot of 100 items is submitted for inspection. Inspection Level IV, normal inspection, with AQL - .4% is to be used. From Tables A-2 and C-1 it is seen that a sample of size 10 is required. Suppose the values of the sample resistances in the order reading from left to right are as follows:

643, 651, 619, 627, 658, (R_1 = 658 - 619 = 39)
670, 673, 641, 638, 650, (R_2 = 673 - 638 = 35)

and compliance with the acceptability criterion is to be determined.

Line	Information Needed	Value Obtained	Explanation
1	Sample Size: n	10	
2	Sum of Measurements: ΣX	6470	
3	Sample Mean $\bar{X}$: $\Sigma X/n$	647	6470/10
4	Average Range $\bar{R}$: ΣR/no. of subgroups	37	(39+35)/2
5	Factor c	2.405	See Table C-3
6	Specification Limit (Lower): L	620	
7	Quality Index: $Q_L = (\bar{X}-L)c/\bar{R}$	1.76	(647-620)2.405/37
8	Est. of Lot Percent Def.: p_L	2.54%	See Table C-5
9	Max. Allowable Percent Def.: M	1.14%	See Table C-3
10	Acceptability Criterion: Compare p_L with M	2.54% > 1.14%	See Para. C6.4

The lot does not meet the acceptability criterion, since p_L is greater than M.

NOTE: If a single upper specification limit U is given, then compute the quality index $Q_U = (U-\bar{X})c/\bar{R}$ in line 7 and obtain the estimate of lot percent defective p_U. Compare p_U with M; the lot meets the acceptability criterion, if p_U is equal to or less than M.

TABLE C-1

Range Method

Master Table for Normal and Tightened Inspection for Plans Based on Variability Unknown
(Single Specification Limit—Form 1)

Sample size code letter	Sample size	Acceptable Quality Levels (normal inspection)													
		.04	.065	.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00	15.00
		k	k	k	k	k	k	k	k	k	k	k	k	k	k
B	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	.587	.502	.401	.296	.178
C	4	↓	↓	↓	↓	↓	↓	↓	.651	.598	.525	.450	.364	.276	.176
D	5	↓	↓	↓	↓	↓	↓	.663	.614	.565	.498	.431	.352	.272	.184
E	7	↓	↓	↓	↓	.702	.659	.613	.569	.525	.465	.405	.336	.266	.189
F	10	↓	↓	↓	.916	.863	.811	.755	.703	.650	.579	.507	.424	.341	.252
G	15	1.09	1.04	.999	.958	.903	.850	.792	.738	.684	.610	.536	.452	.368	.276
H	25	1.14	1.10	1.05	1.01	.951	.896	.835	.779	.723	.647	.571	.484	.398	.305
I	30	1.15	1.10	1.06	1.02	.959	.904	.843	.787	.730	.654	.577	.490	.403	.310
J	35	1.16	1.11	1.07	1.02	.964	.908	.848	.791	.734	.658	.581	.494	.406	.313
K	40	1.18	1.13	1.08	1.04	.978	.921	.860	.803	.746	.668	.591	.503	.415	.321
L	50	1.19	1.14	1.09	1.05	.988	.931	.893	.812	.754	.676	.598	.510	.421	.327
M	60	1.21	1.16	1.11	1.06	1.00	.948	.885	.826	.768	.689	.610	.521	.432	.336
N	85	1.23	1.17	1.13	1.08	1.02	.962	.899	.839	.780	.701	.621	.530	.441	.345
O	115	1.24	1.19	1.14	1.09	1.03	.975	.911	.851	.791	.711	.631	.539	.449	.353
P	175	1.26	1.21	1.16	1.11	1.05	.994	.929	.868	.807	.726	.644	.552	.460	.363
Q	230	1.27	1.21	1.16	1.12	1.06	.996	.931	.870	.809	.728	.645	.553	.462	.364
		.065	.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00	15.00	
		Acceptable Quality Levels (tightened inspection)													

All AQL values are in percent defective.

↓ Use first sampling plan below arrow, that is, both sample size as well as k value. When sample size equals or exceeds lot size, every item in the lot must be inspected.

Range Method

TABLE C-2

Master Table for Reduced Inspection for Plans Based on Variability Unknown
(Single Specification Limit—Form 1)

Sample size code letter	Sample size	Acceptable Quality Levels												
		.04	.065	.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00
		k	k	k	k	k	k	k	k	k	k	k	k	k
B	3	↓	↓	↓	↓	↓	↓	↓	↓	.587	.502	.401	.296	.178
C	3									.587	.502	.401	.296	.178
D	3									.587	.502	.401	.296	.178
E	3									.587	.502	.401	.296	.178
F	4							.651	.598	.525	.450	.364	.276	.176
G	5						.663	.614	.565	.498	.431	.352	.272	.184
H	7				.702	.659	.613	.569	.525	.465	.405	.336	.266	.189
I	10			.916	.863	.811	.755	.703	.650	.579	.507	.424	.341	.252
J	10			.916	.863	.811	.755	.703	.650	.579	.507	.424	.341	.252
K	15	1.04	.999	.958	.903	.850	.792	.738	.684	.610	.536	.452	.368	.276
L	25	1.10	1.05	1.01	.951	.896	.835	.779	.723	.647	.571	.484	.398	.305
M	25	1.10	1.05	1.01	.951	.896	.835	.779	.723	.647	.571	.484	.398	.305
N	30	1.10	1.06	1.02	.959	.904	.843	.787	.730	.654	.577	.490	.403	.310
O	35	1.11	1.07	1.02	.964	.908	.848	.791	.734	.658	.581	.494	.406	.313
P	60	1.16	1.11	1.06	1.00	.948	.885	.826	.768	.689	.610	.521	.432	.336
Q	85	1.17	1.13	1.08	1.02	.962	.899	.839	.780	.701	.621	.530	.441	.345

All AQL values are in percent defective.

↓ Use first sampling plan below arrow, that is, both sample size as well as k value. When sample size equals or exceeds lot size, every item in the lot must be inspected.

Part II

DOUBLE SPECIFICATION LIMIT

C8. SAMPLING PLAN FOR DOUBLE SPECIFICATION LIMIT

This part of the Standard describes the procedures for use with plans for a double specification limit when variability of the lot with respect to the quality characteristic is unknown and the range method is used.

C8.1 Use of Sampling Plans. To determine whether the lot meets the acceptability criterion with respect to a particular quality characteristic and AQL value(s), the applicable sampling plan shall be used in accordance with the provisions of Section A, General Description of Sampling Plans, and those in this part of the Standard.

C9. SELECTING THE SAMPLING PLAN

A sampling plan for each AQL value shall be selected from Table C-3 or C-4 as follows:

C9.1 Determination of Sample Size Code Letter. The sample size code letter shall be selected from Table A-2 in accordance with paragraph A7.1.

C9.2 Master Sampling Tables. The master sampling tables for plans based on variability unknown for a double specification limit when using the range method are Tables C-3 and C-4. Table C-3 is used for normal and tightened inspection and Table C-4 for reduced inspection.

C9.3 Obtaining Sampling Plan. A sampling plan consists of a sample size and the associated maximum allowable percent defective(s). The sampling plan to be applied in inspection shall be obtained from Master Table C-3 or C-4.

C9.3.1 Sample Size. The sample size n is shown in the master tables corresponding to each sample size code letter.

C9.3.2 Maximum Allowable Percent Defective. The maximum allowable percent defective for sample estimates of percent defective for the lower, upper, or both specification limits combined, corresponding to the sample size mentioned in paragraph C9.3.1, is shown in the column of the master table corresponding to the applicable AQL value(s). If different AQL's are assigned to each specification limit, designate the maximum allowable percent defective by M_L for the lower limit, and by M_U for the upper limit. If one AQL is assigned to both limits combined, designate the maximum allowable percent defective by M. Table C-3 is entered from the top for normal inspection and from the bottom for tightened inspection. Sampling plans for reduced inspection are provided in Table C-4.

C10. DRAWING OF SAMPLES

Samples shall be selected in accordance with paragraph A7.2.

C11. LOT-BY-LOT ACCEPTABILITY PROCEDURES

C11.1 Acceptability Criterion. The degree of conformance of a quality characteristic with respect to a double specification limit shall be judged by the percent of nonconforming product. The percentage of nonconforming product is estimated by entering Table C-5 with the quality index and the sample size.

C11.2 Computation of Quality Indices. The quality indices $Q_U = (U-\bar{X})c/\bar{R}$ and $Q_L = (\bar{X}-L)c/\bar{R}$ shall be computed, where

U is the upper specification limit,
L is the lower specification limit,
c is a factor provided in Tables C-3 and C-4,
$\bar{X}$ is the sample mean, and
$\bar{R}$ is the average range of the sample.

In this Standard, $\bar{R}$ is the average range of the subgroup ranges. Each of the subgroups consists of 5 measurements, except for those plans with sample size 3, 4, or 7 in which case the subgroup size is the same as the sample size. In computing $\bar{R}$, the order of the sample measurements as made must be retained. Subgroups of consecutive measurements must be formed and the range of each subgroup obtained. $\bar{R}$ is the average of the individual subgroup ranges.

C11.3 Percent Defective in the Lot. The quality of a lot shall be expressed in terms of the lot percent defective. Its estimate will be designated by p_L, p_U, or p. The estimate p_U indicates conformance with respect to the upper specification limit, p_L with respect to the lower specification limit, and p for both specification limits combined. The

estimates p_L and p_U shall be determined by entering Table C-5, respectively with Q_L and Q_U and the sample size. The estimate p shall be determined by adding the corresponding estimated percent defectives p_L and p_U found in the table.

C12. ACCEPTABILITY CRITERION AND SUMMARY FOR OPERATION OF SAMPLING PLANS

C12.1 One AQL value for both Upper and Lower Specification Limit Combined.

C12.1.1 Acceptability Criterion.[4] Compare the estimated lot percent defective $p = p_U + p_L$ with the maximum allowable percent defective M. If p is equal to or less than M, the lot meets the acceptability criterion; if p is greater than M or if either Q_U or Q_L or both are negative, then the lot does not meet the acceptability criterion.

C12.1.2 *Summary for Operation of Sampling Plan.* In cases where a single AQL value is established for the upper and lower specification limit combined for a single quality characteristic, the following steps summarize the procedures to be used:

(1) Determine the sample size code letter from Table A-2 by using the lot size and the inspection level.

(2) Select plan from Master Table C-3 or C-4. Obtain the sample size n, the factor c, and the maximum allowable percent defective M.

(3) Select at random the sample of n units from the lot; inspect and record the measurement of the quality characteristic on each unit of the sample.

(4) Compute the sample mean $\bar{X}$ and average range of the sample $\bar{R}$.

(5) Compute the quality indices $Q_U = (U-\bar{X})c/\bar{R}$ and $Q_L = (\bar{X}-L)c/\bar{R}$.

(6) Determine the estimated lot percent defective $p = p_U + p_L$ from Table C-5.

(7) If the estimated lot percent defective p is equal to or less than the maximum allowable percent defective M, the lot meets the acceptability criterion; if p is greater than M or if either Q_U or Q_L or both are negative, then the lot does not meet the acceptability criterion.

C12.2 Different AQL values for Upper and Lower Specification Limit.

C12.2.1 Acceptability Criteria.[5] Compare the estimated lot percent defectives p_L and p_U with the corresponding maximum allowable percent defectives M_L and M_U; also compare $p = p_L + p_U$ with the larger of M_L and M_U. If p_L is equal to or less than M_L, p_U is equal to or less than M_U, and p is equal to or less than the larger of M_L and M_U, the lot meets the acceptability criteria; otherwise, the lot does not meet the acceptability criteria. If either Q_L or Q_U or both are negative, then the lot does not meet the acceptability criteria.

C12.2.2 Summary for Operation of Sampling Plan. In cases where a different AQL value is established for the upper and lower specification limit for a single quality characteristic, the following steps summarize the procedures to be used:

(1) Determine the sample size code letter from Table A-2 by using the lot size and inspection level.

(2) Select the sampling plan from Master Table C-3 or C-4. Obtain the sample size n, the factor c, and the maximum allowable percent defectives M_U and M_L, corresponding to AQL values for the upper and lower specification limits, respectively.

(3) Select at random the sample of n units from the lot; inspect and record the measurement of the quality characteristic on each unit in the sample.

(4) Compute the sample mean $\bar{X}$ and average range of the sample $\bar{R}$.

(5) Compute the quality indices $Q_U = (U-\bar{X})c/\bar{R}$ and $Q_L = (\bar{X}-L)c/\bar{R}$.

(6) Determine the estimated lot percent defectives p_U and p_L, corresponding to the percent defectives above the upper and below the lower specification limits. Also determine the combined percent defective $p = p_U + p_L$.

(7) If all three of the following conditions:

(a) p_U is equal to or less than M_U.

(b) p_L is equal to or less than M_L.

(c) p is equal to or less than the larger of M_L and M_U,

are satisfied, the lot meets the acceptability criteria; otherwise, the lot does not meet the acceptability criteria. If either Q_L or Q_U or both are negative, then the lot does not meet the acceptability criteria.

[4] See Example C-3 for a complete example of this procedure.
[5] See Example C-4 for a complete example of this procedure.

EXAMPLE C-3

Example of Calculations

Double Specification Limit

Variability Unknown - Average Range Method

One AQL Value for Both Upper and Lower Specification Limit Combined

Example The specifications for electrical resistance of a certain electrical component is 650.0 ± 30 ohms. A lot of 100 items is submitted for inspection. Inspection Level IV, normal inspection, with AQL = .4% is to be used. From Tables A-2 and C-3 it is seen that a sample of size 10 is required. Suppose the values of the sample resistance in the order reading from left to right are as follows:

643, 651, 619, 627, 658, (R_1 = 658 - 619 = 39)
670, 673, 641, 638, 650, (R_2 = 673 - 638 = 35)

and compliance with the acceptability criterion is to be determined.

Line	Information Needed	Value Obtained	Explanation
1	Sample Size: n	10	
2	Sum of Measurements: ΣX	6470	
3	Sample Mean $\bar{X}$: $\Sigma X/n$	647	6470/10
4	Average Range $\bar{R}$: ΣR/no. of subgroups	37	(39 + 35)/2
5	Factor c	2.405	See Table C-3
6	Upper Specification Limit: U	680	
7	Lower Specification Limit: L	620	
8	Quality Index: $Q_U = (U-\bar{X})c/\bar{R}$	2.15	(680-647)2.405/37
9	Quality Index: $Q_L = (\bar{X}-L)c/\bar{R}$	1.76	(647-620)2.405/37
10	Est. of Lot Percent Def. above U: p_U	.35%	See Table C-5
11	Est. of Lot Percent Def. below L: p_L	2.54%	See Table C-5
12	Total Est. Percent Def. in Lot: $p = p_U + p_L$	2.89%	.35% + 2.54%
13	Max. Allowable Percent Def.: M	1.14%	See Table C-3
14	Acceptability Criterion: Compare $p = p_U + p_L$ with M	2.89% > 1.14%	See Para. C12.1.2(7)

The lot does not meet the acceptability criterion, since $p = p_U + p_L$ is greater than M.

EXAMPLE C-4

Example of Calculations

Double Specification Limit

Variability Unknown - Average Range Method

Different AQL Values for Upper and Lower Specification Limits

Example The specifications for electrical resistance of a certain electrical component is 650.0 ± 30 ohms. A lot of 100 items is submitted for inspection. Inspection Level IV, normal inspection, with AQL = 2.5% for the upper and AQL = 1% for the lower specification limit is to be used. From Tables A-2 and C-3 it is seen that a sample of size 10 is required. Suppose the values of the sample resistances in the order reading from left to right are as follows:

643, 651, 619, 627, 658, (R_1 = 658 - 619 = 39)
670, 673, 641, 638, 650, (R_2 = 673 - 638 = 35)

and compliance with the acceptability criteria is to be determined.

Line	Information Needed	Value Obtained	Explanation
1	Sample Size: n	10	
2	Sum of Measurements: ΣX	6470	
3	Sample Mean $\bar{X}$: $\Sigma X/n$	647	6470/10
4	Average Range $\bar{R}$: ΣR/no. of subgroups	37	(39 + 35)/2
5	Factor c	2.405	See Table C-3
6	Upper Specification Limit: U	680	
7	Lower Specification Limit: L	620	
8	Quality Index: $Q_U = (U-\bar{X})c/\bar{R}$	2.15	(680-647)2.405/37
9	Quality Index: $Q_L = (\bar{X}-L)c/\bar{R}$	1.76	(647-620)2.405/37
10	Est. of Lot Percent Def. above U: p_U	.35%	See Table C-5
11	Est. of Lot Percent Def. below L: p_L	2.54%	See Table C-5
12	Total Est. Percent Def. in Lot: $p = p_U + p_L$	2.89%	.35% + 2.54%
13	Max. Allowable Percent Def. above U: M_U	7.42%	See Table C-3
14	Max. Allowable Percent Def. below L: M_L	3.23%	See Table C-3
15	Acceptability Criteria: (a) Compare p_U with M_U	.35% < 7.42%	See Para. C12.2.2(7)(a)
	(b) Compare p_L with M_L	2.54% < 3.23%	See Para. C12.2.2(7)(b)
	(c) Compare p with M_U	2.89% < 7.42%	See Para. C12.2.2(7)(c)

The lot meets the acceptability criteria, since 15(a), (b) and (c) are satisfied, i.e., $p_U < M_U$, $p_L < M_L$ and $p < M_U$.

Range Method

TABLE C-3

Master Table for Normal and Tightened Inspection for Plans Based on Variability Unknown
(Double Specification Limit and for Form 2—Single Specification Limit)

Sample size code letter	Sample size	c factor	Acceptable Quality Levels (normal inspection)													
			.04	.065	.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00	15.00
			M	M	M	M	M	M	M	M	M	M	M	M	M	M
B	3	1.910	↓	↓	↓	↓	↓	↓	↓	↓	↓	7.59	18.86	26.94	33.69	40.47
C	4	2.234	↓	↓	↓	↓	↓	↓	↓	1.53	5.50	10.92	16.45	22.86	29.45	36.90
D	5	2.474	↓	↓	↓	↓	↓	↓	1.42	3.44	5.93	9.90	14.47	20.27	26.59	33.95
E	7	2.830	↓	↓	↓	↓	.28	.89	1.99	3.46	5.32	8.47	12.35	17.54	23.50	30.66
F	10	2.405	↓	↓	↓	.23	.58	1.14	2.05	3.23	4.77	7.42	10.79	15.49	21.06	27.90
G	15	2.379	.061	.136	.253	.430	.786	1.30	2.10	3.11	4.44	6.76	9.76	14.09	19.30	25.92
H	25	2.358	.125	.214	.336	.506	.827	1.27	1.95	2.82	3.96	5.98	8.65	12.59	17.48	23.79
I	30	2.353	.147	.240	.366	.537	.856	1.29	1.96	2.81	3.92	5.88	8.50	12.36	17.19	23.42
J	35	2.349	.165	.261	.391	.564	.883	1.33	1.98	2.82	3.90	5.85	8.42	12.24	17.03	23.21
K	40	2.346	.160	.252	.375	.539	.842	1.25	1.88	2.69	3.73	5.61	8.11	11.84	16.55	22.38
L	50	2.342	.169	.261	.381	.542	.838	1.25	1.60	2.63	3.64	5.47	7.91	11.57	16.20	22.26
M	60	2.339	.158	.244	.356	.504	.781	1.16	1.74	2.47	3.44	5.17	7.54	11.10	15.64	21.63
N	85	2.335	.156	.242	.350	.493	.755	1.12	1.67	2.37	3.30	4.97	7.27	10.73	15.17	21.05
O	115	2.333	.153	.230	.333	.468	.718	1.06	1.58	2.25	3.14	4.76	6.99	10.37	14.74	20.57
P	175	2.331	.139	.210	.303	.427	.655	.972	1.46	2.08	2.93	4.47	6.60	9.89	14.15	19.88
Q	230	2.330	.142	.215	.308	.432	.661	.976	1.47	2.08	2.92	4.46	6.57	9.84	14.10	19.82
			.065	.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00	15.00	
			Acceptable Quality Levels (tightened inspection)													

All AQL and table values are in percent defective.

↓ Use first sampling plan below arrow, that is, both sample size as well as M value. When sample size equals or exceeds lot size, every item in the lot must be inspected.

Range Method

TABLE C-4

Master Table for Reduced Inspection for Plans Based on Variability Unknown
(Double Specification Limit and Form 2—Single Specification Limit)

Sample size code letter	Sample size	c factor	Acceptable Quality Levels												
			.04	.065	.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00
			M	M	M	M	M	M	M	M	M	M	M	M	M
B	3	1.910									7.59	18.86	26.94	33.69	40.47
C	3	1.910									7.59	18.86	26.94	33.69	40.47
D	3	1.910									7.59	18.86	26.94	33.69	40.47
E	3	1.910									7.59	18.86	26.94	33.69	40.47
F	4	2.234							1.53	5.50	10.92	16.45	22.86	29.45	36.90
G	5	2.474						1.42	3.44	5.93	9.90	14.47	20.27	26.59	33.95
H	7	2.830				.28	.89	1.99	3.46	5.32	8.47	12.35	17.54	23.50	30.66
I	10	2.405			.23	.58	1.14	2.05	3.23	4.77	7.42	10.79	15.49	21.06	27.90
J	10	2.405			.23	.58	1.14	2.05	3.23	4.77	7.42	10.79	15.49	21.06	27.90
K	15	2.379	.136	.253	.430	.786	1.30	2.10	3.11	4.44	6.76	9.76	14.09	19.30	25.92
L	25	2.358	.214	.336	.506	.827	1.27	1.95	2.82	3.96	5.98	8.65	12.59	17.48	23.79
M	25	2.358	.214	.336	.506	.827	1.27	1.95	2.82	3.96	5.98	8.65	12.59	17.48	23.79
N	30	2.353	.240	.366	.537	.856	1.29	1.96	2.81	3.92	5.88	8.50	12.36	17.19	23.42
O	35	2.349	.261	.391	.564	.883	1.33	1.98	2.82	3.90	5.85	8.42	12.24	17.03	23.21
P	60	2.339	.244	.356	.504	.781	1.16	1.74	2.47	3.44	5.17	7.54	11.10	15.64	21.63
Q	85	2.335	.242	.350	.493	.755	1.12	1.67	2.37	3.30	4.97	7.27	10.73	15.17	21.05

All AQL and table values are in percent defective.
↓ Use first sampling plan below arrow, that is, both sample size as well as M value. When sample size equals or exceeds lot size, every item in the lot must be inspected.

TABLE C-5

Table for Estimating the Lot Percent Defective Using Range Method[1]

Q_U or Q_L	Sample Size															
	3	4	5	7	10	15	25	30	35	40	50	60	85	115	175	230
0	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
.1	47.24	46.67	46.44	46.29	46.20	46.13	46.08	46.07	46.06	46.05	46.05	46.04	46.03	46.03	46.02	46.02
.2	44.46	43.33	42.90	42.60	42.42	42.29	42.19	42.17	42.16	42.15	42.13	42.12	42.10	42.10	42.08	42.08
.3	41.63	40.00	39.37	38.95	38.70	38.51	38.38	38.34	38.32	38.31	38.28	38.27	38.26	38.24	38.23	38.22
.31	41.35	39.67	39.02	38.59	38.33	38.14	38.00	37.96	37.94	37.93	37.90	37.89	37.88	37.86	37.85	37.84
.32	41.06	39.33	38.67	38.23	37.96	37.77	37.63	37.59	37.57	37.55	37.53	37.51	37.50	37.48	37.47	37.46
.33	40.77	39.00	38.32	37.87	37.60	37.39	37.25	37.21	37.19	37.18	37.15	37.14	37.12	37.11	37.09	37.09
.34	40.49	38.67	37.97	37.51	37.23	37.02	36.88	36.84	36.82	36.80	36.77	36.76	36.74	36.73	36.71	36.71
.35	40.20	38.33	37.62	37.15	36.87	36.65	36.50	36.46	36.44	36.43	36.40	36.39	36.37	36.36	36.34	36.33
.36	39.91	38.00	37.28	36.79	36.50	36.29	36.13	36.09	36.07	36.05	36.03	36.01	35.99	35.97	35.96	35.96
.37	39.62	37.67	36.93	36.43	36.14	35.92	35.76	35.72	35.70	35.68	35.65	35.64	35.62	35.61	35.59	35.59
.38	39.33	37.33	36.58	36.07	35.78	35.55	35.39	35.35	35.33	35.31	35.28	35.27	35.25	35.24	35.22	35.22
.39	39.03	37.00	36.23	35.72	35.41	35.19	35.02	34.98	34.96	34.94	34.92	34.90	34.88	34.87	34.85	34.85
.40	38.74	36.67	35.88	35.36	35.05	34.82	34.66	34.62	34.59	34.58	34.55	34.53	34.51	34.49	34.48	34.48
.41	38.45	36.33	35.54	35.01	34.69	34.46	34.29	34.25	34.23	34.21	34.18	34.17	34.14	34.12	34.11	34.11
.42	38.15	36.00	35.19	34.65	34.33	34.10	33.93	33.89	33.86	33.85	33.82	33.80	33.78	33.77	33.75	33.74
.43	37.85	35.67	34.85	34.30	33.98	33.74	33.57	33.53	33.50	33.48	33.45	33.44	33.41	33.39	33.38	33.38
.44	37.56	35.33	34.50	33.95	33.62	33.38	33.21	33.17	33.14	33.12	33.09	33.08	33.05	33.03	33.02	33.02
.45	37.26	35.00	34.16	33.60	33.27	33.02	32.85	32.81	32.78	32.76	32.73	32.72	32.69	32.67	32.66	32.66
.46	36.96	34.67	33.81	33.26	32.91	32.66	32.49	32.45	32.42	32.40	32.37	32.36	32.33	32.31	32.30	32.30
.47	36.66	34.33	33.47	32.89	32.56	32.31	32.13	32.09	32.06	32.04	32.01	32.00	31.97	31.95	31.94	31.94
.48	36.35	34.00	33.12	32.55	32.21	31.96	31.78	31.74	31.71	31.69	31.66	31.64	31.62	31.61	31.59	31.58
.49	36.05	33.67	32.78	32.20	31.86	31.60	31.42	31.38	31.35	31.33	31.30	31.29	31.26	31.26	31.23	31.23
.50	35.75	33.33	32.44	31.85	31.51	31.25	31.07	31.03	31.00	30.98	30.95	30.94	30.91	30.89	30.88	30.87
.51	35.44	33.00	32.10	31.51	31.16	30.90	30.72	30.68	30.65	30.63	30.60	30.59	30.55	30.55	30.53	30.52
.52	35.13	32.67	31.76	31.16	30.81	30.55	30.37	30.33	30.30	30.28	30.25	30.24	30.21	30.19	30.18	30.17
.53	34.82	32.33	31.42	30.82	30.46	30.21	30.02	29.98	29.95	29.93	29.90	29.89	29.86	29.84	29.83	29.83
.54	34.51	32.00	31.08	30.47	30.12	29.86	29.68	29.64	29.61	29.59	29.56	29.54	29.52	29.50	29.48	29.48
.55	34.20	31.67	30.74	30.13	29.78	29.52	29.33	29.29	29.26	29.24	29.21	29.20	29.17	29.15	29.14	29.14
.56	33.88	31.33	30.40	29.79	29.44	29.18	28.99	28.95	28.92	28.90	28.87	28.86	28.83	28.81	28.80	28.79
.57	33.57	31.00	30.06	29.45	29.09	28.83	28.65	28.61	28.58	28.56	28.53	28.52	28.49	28.47	28.46	28.45
.58	33.25	30.67	29.73	29.11	28.76	28.50	28.31	28.27	28.24	28.22	28.19	28.18	28.15	28.13	28.12	28.12
.59	32.93	30.33	29.39	28.77	28.42	28.16	27.97	27.93	27.91	27.89	27.86	27.84	27.82	27.80	27.78	27.78
.60	32.61	30.00	29.05	28.44	28.08	27.82	27.64	27.60	27.57	27.55	27.52	27.51	27.48	27.46	27.45	27.45
.61	32.28	29.67	28.72	28.10	27.75	27.49	27.31	27.27	27.24	27.22	27.19	27.17	27.15	27.14	27.12	27.11
.62	31.96	29.33	28.39	27.77	27.41	27.16	26.97	26.93	26.91	26.89	26.86	26.84	26.82	26.81	26.79	26.78
.63	31.63	29.00	28.05	27.44	27.08	26.82	26.64	26.60	26.58	26.56	26.53	26.51	26.49	26.48	26.46	26.45
.64	31.30	28.67	27.72	27.11	26.75	26.50	26.32	26.28	26.25	26.23	26.20	26.19	26.16	26.14	26.13	26.13
.65	30.97	28.33	27.39	26.78	26.42	26.17	25.99	25.95	25.92	25.90	25.87	25.86	25.84	25.83	25.81	25.80
.66	30.63	28.00	27.06	26.45	26.10	25.84	25.67	25.63	25.60	25.58	25.55	25.54	25.52	25.50	25.48	25.48
.67	30.30	27.67	26.73	26.12	25.77	25.52	25.34	25.30	25.28	25.26	25.23	25.22	25.20	25.18	25.16	25.16
.68	29.96	27.33	26.40	25.79	25.45	25.20	25.02	24.98	24.96	24.94	24.91	24.90	24.88	24.87	24.85	24.84
.69	29.61	27.00	26.07	25.47	25.12	24.88	24.71	24.67	24.64	24.62	24.59	24.58	24.56	24.55	24.53	24.53
.70	29.27	26.67	25.74	25.14	24.80	24.56	24.39	24.35	24.32	24.31	24.28	24.27	24.25	24.24	24.22	24.21
.71	28.92	26.33	25.41	24.82	24.48	24.24	24.07	24.03	24.01	23.99	23.97	23.95	23.93	23.91	23.90	23.90
.72	28.57	26.00	25.09	24.50	24.17	23.93	23.76	23.72	23.70	23.68	23.66	23.64	23.62	23.60	23.59	23.59
.73	28.22	25.67	24.76	24.18	23.85	23.61	23.45	23.41	23.39	23.37	23.35	23.33	23.32	23.30	23.29	23.29
.74	27.86	25.33	24.44	23.86	23.54	23.30	23.14	23.10	23.08	23.07	23.04	23.03	23.01	23.00	22.98	22.98
.75	27.50	25.00	24.11	23.55	23.22	22.99	22.84	22.80	22.78	22.76	22.74	22.72	22.71	22.69	22.66	22.66
.76	27.13	24.67	23.78	23.23	22.91	22.69	22.53	22.49	22.47	22.46	22.43	22.42	22.41	22.39	22.38	22.38
.77	26.77	24.33	23.47	22.92	22.60	22.38	22.23	22.19	22.17	22.16	22.13	22.12	22.11	22.09	22.08	22.08
.78	26.39	24.00	23.15	22.60	22.30	22.08	21.93	21.90	21.88	21.86	21.85	21.83	21.81	21.80	21.78	21.78
.79	26.02	23.67	22.83	22.29	21.99	21.78	21.64	21.60	21.58	21.57	21.54	21.53	21.52	21.50	21.49	21.49
.80	25.64	23.33	22.51	21.98	21.69	21.48	21.34	21.30	21.28	21.27	21.26	21.24	21.22	21.22	21.20	21.20
.81	25.25	23.00	22.19	21.68	21.39	21.18	21.04	21.01	20.99	20.98	20.97	20.95	20.93	20.93	20.91	20.91
.82	24.86	22.67	21.87	21.37	21.09	20.89	20.75	20.72	20.70	20.69	20.68	20.66	20.64	20.64	20.62	20.62
.83	24.47	22.33	21.56	21.06	20.79	20.59	20.46	20.43	20.41	20.40	20.38	20.37	20.36	20.35	20.34	20.34
.84	24.07	22.00	21.24	20.76	20.49	20.30	20.17	20.15	20.13	20.12	20.10	20.09	20.08	20.06	20.06	20.06
.85	23.67	21.67	20.93	20.46	20.20	20.01	19.89	19.87	19.85	19.84	19.82	19.81	19.79	19.79	19.78	19.78
.86	23.26	21.33	20.62	20.16	19.90	19.73	19.60	19.58	19.57	19.56	19.54	19.54	19.52	19.51	19.50	19.50
.87	22.84	21.00	20.31	19.86	19.61	19.44	19.32	19.31	19.29	19.28	19.26	19.25	19.24	19.24	19.22	19.22
.88	22.42	20.67	20.00	19.57	19.33	19.16	19.04	19.03	19.01	19.00	18.98	18.98	18.97	18.96	18.95	18.95
.89	21.99	20.33	19.69	19.27	19.04	18.88	18.77	18.75	18.74	18.73	18.71	18.70	18.69	18.69	18.68	18.68
.90	21.55	20.00	19.36	18.98	18.75	18.60	18.50	18.48	18.47	18.46	18.44	18.43	18.42	18.42	18.41	18.41
.91	21.11	19.67	19.07	18.69	18.47	18.32	18.22	18.21	18.20	18.19	18.17	18.17	18.17	18.16	18.15	18.15
.92	20.66	19.33	18.77	18.40	18.19	18.05	17.96	17.95	17.93	17.92	17.92	17.90	17.89	17.89	17.88	17.88
.93	20.20	19.00	18.46	18.11	17.91	17.78	17.69	17.68	17.67	17.66	17.65	17.65	17.63	17.63	17.62	17.62
.94	19.74	18.67	18.16	17.82	17.64	17.51	17.43	17.42	17.41	17.40	17.39	17.39	17.37	17.37	17.36	17.36
.95	19.25	18.33	17.86	17.54	17.36	17.24	17.17	17.16	17.15	17.14	17.13	17.13	17.12	17.12	17.11	17.11
.96	18.76	18.00	17.56	17.26	17.09	16.98	16.91	16.90	16.89	16.88	16.88	16.87	16.86	16.86	16.86	16.86
.97	18.25	17.67	17.25	16.97	16.82	16.71	16.65	16.64	16.63	16.63	16.62	16.62	16.61	16.61	16.60	16.60
.98	17.74	17.33	16.96	16.70	16.55	16.45	16.39	16.38	16.38	16.37	16.37	16.37	16.36	16.36	16.36	16.36
.99	17.21	17.00	16.66	16.42	16.28	16.19	16.14	16.13	16.13	16.12	16.12	16.12	16.11	16.11	16.11	16.11
1.00	16.67	16.67	16.36	16.14	16.02	15.94	15.89	15.88	15.88	15.88	15.87	15.87	15.87	15.87	15.87	15.87
1.01	16.11	16.33	16.07	15.87	15.76	15.68	15.64	15.63	15.63	15.63	15.63	15.63	15.62	15.62	15.62	15.62
1.02	15.53	16.00	15.78	15.60	15.50	15.43	15.40	15.39	15.39	15.39	15.39	15.39	[illegible]	15.38	15.38	15.38
1.03	14.93	15.67	15.48	15.33	15.26	15.18	15.15	15.15	15.15	15.15	15.15	15.15	15.15	15.15	15.15	15.15
1.04	14.31	15.33	15.19	15.06	14.98	14.94	14.91	14.91	14.91	14.91	14.91	14.91	14.91	14.91	14.91	14.91
1.05	13.66	15.00	14.91	14.79	14.73	14.69	14.67	14.67	14.67	14.67	14.67	14.68	14.68	14.68	14.68	14.68
1.06	12.98	14.67	14.62	14.53	14.48	14.45	14.44	14.44	14.44	14.44	14.44	14.44	14.45	14.45	14.45	14.45
1.07	12.27	14.33	14.33	14.27	14.23	14.21	14.20	14.21	14.21	14.21	14.21	14.21	14.22	14.22	14.22	14.22
1.08	11.51	14.00	14.05	14.01	13.98	13.97	13.97	13.98	13.98	13.98	13.98	13.98	13.99	13.99	14.00	14.00
1.09	10.71	13.67	13.76	13.75	13.74	13.73	13.74	13.75	13.75	13.75	13.76	13.76	13.77	13.77	13.78	13.78

[1]Values tabulated are read in percent.

TABLE C-5--Continued

Table for Estimating the Lot Percent Defective Using Range Method

Q_U or Q_L	Sample Size 3	4	5	7	10	15	25	30	35	40	50	60	85	115	175	230
1.10	9.56	13.33	13.48	13.50	13.49	13.50	13.52	13.52	13.52	13.53	13.54	13.54	13.55	13.55	13.56	13.56
1.11	8.89	13.00	13.20	13.26	13.25	13.27	13.29	13.30	13.30	13.31	13.31	13.32	13.32	13.33	13.34	13.34
1.12	7.82	12.67	12.93	12.99	13.02	13.04	13.07	13.08	13.08	13.09	13.10	13.10	13.12	13.12	13.12	13.12
1.13	6.60	12.33	12.65	12.74	12.78	12.81	12.85	12.86	12.86	12.87	12.89	12.89	12.89	12.90	12.91	12.91
1.14	5.08	12.00	12.37	12.49	12.55	12.59	12.63	12.64	12.65	12.66	12.67	12.67	12.69	12.69	12.70	12.70
1.15	0.29	11.67	12.10	12.25	12.31	12.37	12.42	12.43	12.44	12.45	12.46	12.46	12.48	12.48	12.49	12.49
1.16	0.00	11.33	11.83	12.00	12.08	12.15	12.21	12.22	12.23	12.24	12.25	12.25	12.27	12.28	12.29	12.29
1.17	0.00	11.00	11.56	11.76	11.86	11.93	12.00	12.01	12.02	12.03	12.05	12.06	12.07	12.07	12.08	12.08
1.18	0.00	10.67	11.29	11.52	11.63	11.71	11.79	11.80	11.81	11.82	11.84	11.84	11.86	11.88	11.88	11.88
1.19	0.00	10.33	11.02	11.29	11.41	11.50	11.58	11.60	11.61	11.62	11.64	11.65	11.66	11.68	11.69	11.69
1.20	0.00	10.00	10.76	11.05	11.19	11.29	11.38	11.40	11.41	11.42	11.43	11.45	11.47	11.47	11.49	11.49
1.21	0.00	9.67	10.50	10.82	10.97	11.08	11.18	11.20	11.21	11.22	11.25	11.26	11.27	11.29	11.30	11.30
1.22	0.00	9.33	10.23	10.59	10.76	10.88	10.98	11.00	11.02	11.03	11.04	11.06	11.08	11.09	11.10	11.10
1.23	0.00	9.00	9.97	10.36	10.56	10.67	10.78	10.80	10.82	10.84	10.85	10.87	10.89	10.90	10.91	10.91
1.24	0.00	8.67	9.72	10.13	10.35	10.47	10.58	10.62	10.63	10.64	10.67	10.68	10.70	10.71	10.73	10.73
1.25	0.00	8.33	9.46	9.91	10.12	10.27	10.39	10.42	10.44	10.46	10.47	10.49	10.51	10.52	10.54	10.54
1.26	0.00	8.00	9.21	9.69	9.92	10.08	10.20	10.24	10.26	10.27	10.30	10.31	10.33	10.34	10.36	10.36
1.27	0.00	7.67	8.96	9.47	9.71	9.88	10.01	10.05	10.07	10.09	10.11	10.13	10.15	10.17	10.18	10.18
1.28	0.00	7.33	8.71	9.25	9.51	9.69	9.83	9.87	9.89	9.90	9.93	9.95	9.97	9.99	10.00	10.00
1.29	0.00	7.00	8.46	9.04	9.31	9.50	9.64	9.68	9.71	9.72	9.75	9.77	9.79	9.81	9.83	9.83
1.30	0.00	6.67	8.21	8.83	9.11	9.32	9.47	9.51	9.53	9.55	9.58	9.59	9.62	9.64	9.65	9.65
1.31	0.00	6.33	7.97	8.62	8.92	9.13	9.29	9.33	9.35	9.37	9.40	9.42	9.45	9.47	9.48	9.48
1.32	0.00	6.00	7.73	8.41	8.73	8.95	9.11	9.15	9.18	9.20	9.23	9.25	9.28	9.30	9.31	9.31
1.33	0.00	5.67	7.49	8.20	8.54	8.77	8.94	8.98	9.01	9.03	9.06	9.08	9.11	9.13	9.14	9.15
1.34	0.00	5.33	7.25	8.00	8.35	8.59	8.77	8.81	8.84	8.86	8.89	8.91	8.94	8.96	8.98	8.99
1.35	0.00	5.00	7.02	7.80	8.16	8.41	8.60	8.64	8.67	8.69	8.73	8.75	8.78	8.80	8.82	8.82
1.36	0.00	4.67	6.79	7.60	7.98	8.24	8.43	8.48	8.51	8.53	8.56	8.59	8.62	8.64	8.66	8.66
1.37	0.00	4.33	6.56	7.40	7.80	8.07	8.27	8.31	8.34	8.37	8.40	8.43	8.46	8.48	8.50	8.50
1.38	0.00	4.00	6.33	7.21	7.62	7.90	8.11	8.15	8.18	8.21	8.25	8.26	8.30	8.32	8.34	8.35
1.39	0.00	3.67	6.10	7.02	7.45	7.73	7.95	7.99	8.02	8.05	8.09	8.11	8.14	8.17	8.19	8.19
1.40	0.00	3.33	5.88	6.83	7.27	7.57	7.79	7.84	7.88	7.90	7.93	7.96	8.00	8.02	8.03	8.04
1.41	0.00	3.00	5.66	6.65	7.10	7.41	7.63	7.68	7.71	7.74	7.78	7.81	7.85	7.87	7.88	7.89
1.42	0.00	2.67	5.44	6.46	6.93	7.25	7.48	7.53	7.56	7.59	7.63	7.66	7.70	7.72	7.74	7.74
1.43	0.00	2.33	5.23	6.28	6.76	7.09	7.33	7.38	7.41	7.44	7.49	7.51	7.54	7.57	7.59	7.60
1.44	0.00	2.00	5.01	6.10	6.60	6.93	7.18	7.24	7.28	7.30	7.34	7.37	7.41	7.43	7.45	7.46
1.45	0.00	1.67	4.81	5.93	6.44	6.78	7.03	7.09	7.13	7.15	7.20	7.23	7.27	7.29	7.30	7.32
1.46	0.00	1.33	4.60	5.75	6.28	6.63	6.89	6.95	6.99	7.01	7.06	7.09	7.13	7.15	7.17	7.18
1.47	0.00	1.00	4.39	5.58	6.12	6.48	6.74	6.80	6.85	6.87	6.92	6.95	6.99	7.01	7.03	7.04
1.48	0.00	0.67	4.19	5.41	5.96	6.34	6.60	6.66	6.71	6.73	6.78	6.82	6.85	6.87	6.89	6.90
1.49	0.00	0.33	3.99	5.24	5.81	6.19	6.47	6.53	6.57	6.60	6.64	6.67	6.72	6.74	6.76	6.77

Q_U or Q_L	Sample Size 3	4	5	7	10	15	25	30	35	40	50	60	85	115	175	230
1.50	0.00	0.00	3.80	5.08	5.66	6.05	6.33	6.39	6.43	6.46	6.51	6.54	6.56	6.61	6.63	6.64
1.51	0.00	0.00	3.61	4.92	5.51	5.91	6.19	6.25	6.30	6.33	6.38	6.41	6.45	6.48	6.50	6.51
1.52	0.00	0.00	3.42	4.76	5.37	5.77	6.06	6.12	6.17	6.20	6.25	6.28	6.32	6.35	6.37	6.38
1.53	0.00	0.00	3.23	4.60	5.22	5.64	5.93	5.99	6.04	6.07	6.12	6.15	6.20	6.22	6.25	6.26
1.54	0.00	0.00	3.05	4.45	5.08	5.50	5.80	5.86	5.91	5.95	6.00	6.03	6.07	6.10	6.12	6.14
1.55	0.00	0.00	2.87	4.30	4.94	5.37	5.68	5.74	5.79	5.82	5.87	5.90	5.95	5.98	6.00	6.01
1.56	0.00	0.00	2.69	4.15	4.81	5.24	5.55	5.62	5.67	5.70	5.75	5.78	5.83	5.86	5.88	5.89
1.57	0.00	0.00	2.52	4.01	4.67	5.11	5.43	5.50	5.55	5.58	5.63	5.66	5.71	5.74	5.77	5.79
1.58	0.00	0.00	2.35	3.86	4.54	4.99	5.31	5.38	5.43	5.46	5.52	5.55	5.59	5.62	5.65	5.66
1.59	0.00	0.00	2.19	3.72	4.41	4.86	5.19	5.26	5.31	5.34	5.40	5.43	5.48	5.51	5.53	5.55
1.60	0.00	0.00	2.03	3.58	4.28	4.74	5.08	5.14	5.19	5.23	5.29	5.32	5.36	5.39	5.42	5.43
1.61	0.00	0.00	1.87	3.45	4.16	4.62	4.96	5.03	5.08	5.12	5.17	5.20	5.25	5.28	5.31	5.32
1.62	0.00	0.00	1.72	3.31	4.03	4.51	4.85	4.92	4.97	5.01	5.06	5.09	5.14	5.17	5.20	5.22
1.63	0.00	0.00	1.57	3.18	3.91	4.39	4.74	4.81	4.86	4.90	4.96	4.99	5.04	5.07	5.10	5.12
1.64	0.00	0.00	1.42	3.06	3.79	4.28	4.63	4.70	4.75	4.79	4.85	4.88	4.93	4.96	4.99	5.00
1.65	0.00	0.00	1.28	2.93	3.68	4.17	4.52	4.59	4.64	4.68	4.74	4.77	4.83	4.86	4.89	4.91
1.66	0.00	0.00	1.15	2.81	3.56	4.06	4.41	4.49	4.54	4.58	4.64	4.67	4.72	4.75	4.79	4.81
1.67	0.00	0.00	1.02	2.69	3.45	3.95	4.31	4.39	4.44	4.48	4.54	4.57	4.62	4.65	4.69	4.71
1.68	0.00	0.00	0.89	2.57	3.34	3.85	4.21	4.29	4.34	4.38	4.44	4.47	4.53	4.56	4.59	4.61
1.69	0.00	0.00	0.77	2.44	3.23	3.74	4.10	4.19	4.24	4.28	4.34	4.37	4.43	4.46	4.49	4.51
1.70	0.00	0.00	0.66	2.35	3.13	3.64	4.00	4.09	4.14	4.18	4.24	4.28	4.33	4.36	4.40	4.42
1.71	0.00	0.00	0.55	2.24	3.02	3.54	3.92	3.99	4.05	4.09	4.15	4.18	4.24	4.27	4.30	4.31
1.72	0.00	0.00	0.45	2.13	2.92	3.45	3.82	3.90	3.95	3.99	4.06	4.09	4.15	4.18	4.21	4.23
1.73	0.00	0.00	0.36	2.03	2.82	3.35	3.73	3.81	3.86	3.90	3.96	4.00	4.06	4.09	4.12	4.14
1.74	0.00	0.00	0.27	1.93	2.73	3.26	3.63	3.72	3.77	3.81	3.87	3.91	3.97	4.00	4.03	4.05
1.75	0.00	0.00	0.19	1.83	2.63	3.16	3.54	3.63	3.68	3.72	3.79	3.82	3.88	3.91	3.94	3.96
1.76	0.00	0.00	0.12	1.73	2.54	3.07	3.45	3.54	3.59	3.63	3.70	3.74	3.79	3.82	3.86	3.88
1.77	0.00	0.00	0.06	1.64	2.45	2.99	3.37	3.45	3.51	3.55	3.61	3.65	3.71	3.74	3.77	3.79
1.78	0.00	0.00	0.02	1.55	2.36	2.90	3.28	3.37	3.43	3.47	3.53	3.57	3.62	3.65	3.69	[illegible]
1.79	0.00	0.00	0.00	1.46	2.27	2.81	3.20	3.28	3.34	3.38	3.45	3.49	3.54	3.57	3.61	3.63
1.80	0.00	0.00	0.00	1.38	2.19	2.73	3.11	3.20	3.26	3.30	3.37	3.41	3.46	3.49	3.53	3.55
1.81	0.00	0.00	0.00	1.29	2.10	2.65	3.03	3.12	3.18	3.22	3.29	3.33	3.38	3.41	3.45	3.47
1.82	0.00	0.00	0.00	1.21	2.02	2.57	2.96	3.05	3.11	3.15	3.21	3.25	3.31	3.34	3.37	3.39
1.83	0.00	0.00	0.00	1.14	1.94	2.49	2.88	2.97	3.03	3.07	3.13	3.17	3.23	3.26	3.30	3.32
1.84	0.00	0.00	0.00	1.06	1.87	2.42	2.80	2.89	2.95	2.99	3.06	3.10	3.16	3.19	3.22	3.24
1.85	0.00	0.00	0.00	0.99	1.79	2.34	2.73	2.82	2.88	2.92	2.99	3.03	3.08	3.11	3.15	3.17
1.86	0.00	0.00	0.00	0.92	1.72	2.27	2.66	2.75	2.81	2.85	2.91	2.95	3.01	3.04	3.08	3.10
1.87	0.00	0.00	0.00	0.86	1.65	2.20	2.59	2.68	2.74	2.78	2.84	2.88	2.94	2.97	3.01	3.03
1.88	0.00	0.00	0.00	0.79	1.58	2.13	2.52	2.61	2.67	2.71	2.77	2.81	2.87	2.90	2.94	2.96
1.89	0.00	0.00	0.00	0.73	1.51	2.06	2.45	2.54	2.60	2.64	2.71	2.75	2.81	2.84	2.87	2.89

TABLE C-5—Continued

Table for Estimating the Lot Percent Defective Using Range Method

Q_U or Q_L	Sample Size 3	4	5	7	10	15	25	30	35	40	50	60	85	115	175	230
1.90	0.00	0.00	0.00	0.67	1.45	1.99	2.38	2.47	2.53	2.57	2.64	2.68	2.74	2.77	2.81	2.83
1.91	0.00	0.00	0.00	0.62	1.38	1.93	2.32	2.41	2.47	2.51	2.58	2.61	2.67	2.70	2.74	2.76
1.92	0.00	0.00	0.00	0.56	1.32	1.86	2.25	2.34	2.41	2.45	2.51	2.55	2.61	2.64	2.68	2.70
1.93	0.00	0.00	0.00	0.51	1.26	1.80	2.19	2.28	2.34	2.38	2.45	2.49	2.55	2.58	2.61	2.63
1.94	0.00	0.00	0.00	0.46	1.20	1.74	2.13	2.22	2.28	2.32	2.39	2.43	2.49	2.52	2.55	2.57
1.95	0.00	0.00	0.00	0.42	1.15	1.68	2.07	2.16	2.22	2.26	2.33	2.37	2.43	2.46	2.49	2.51
1.96	0.00	0.00	0.00	0.37	1.09	1.62	2.01	2.10	2.16	2.20	2.27	2.31	2.37	2.40	2.43	2.45
1.97	0.00	0.00	0.00	0.33	1.04	1.57	1.95	2.04	2.10	2.14	2.21	2.25	2.31	2.34	2.38	2.40
1.98	0.00	0.00	0.00	0.30	0.99	1.51	1.90	1.99	2.05	2.09	2.15	2.19	2.25	2.28	2.32	2.31
1.99	0.00	0.00	0.00	0.26	0.94	1.46	1.84	1.93	1.99	2.03	2.10	2.14	2.20	2.23	2.26	2.28
2.00	0.00	0.00	0.00	0.23	0.89	1.41	1.79	1.88	1.94	1.98	2.05	2.08	2.14	2.17	2.21	2.23
2.01	0.00	0.00	0.00	0.20	0.84	1.36	1.74	1.83	1.89	1.93	1.99	2.03	2.09	2.12	2.16	2.18
2.02	0.00	0.00	0.00	0.17	0.80	1.31	1.69	1.78	1.83	1.87	1.94	1.98	2.04	2.07	2.10	2.12
2.03	0.00	0.00	0.00	0.14	0.75	1.26	1.64	1.73	1.78	1.82	1.89	1.93	1.99	2.02	2.05	2.07
2.04	0.00	0.00	0.00	0.12	0.71	1.21	1.59	1.68	1.73	1.77	1.84	1.88	1.94	1.97	2.00	2.02
2.05	0.00	0.00	0.00	0.10	0.67	1.17	1.54	1.63	1.69	1.72	1.79	1.83	1.89	1.92	1.95	1.97
2.06	0.00	0.00	0.00	0.08	0.63	1.12	1.49	1.58	1.64	1.68	1.74		1.84	1.87	1.91	1.93
2.07	0.00	0.00	0.00	0.06	0.60	1.08	1.45	1.54	1.59	1.63	1.70	1.74	1.79	1.82	1.86	1.88
2.08	0.00	0.00	0.00	0.05	0.56	1.04	1.40	1.49	1.55	1.59	1.65	1.69	1.75	1.78	1.81	1.83
2.09	0.00	0.00	0.00	0.03	0.53	1.00	1.36	1.45	1.50	1.54	1.62	1.64	1.70	1.73	1.77	1.79
2.10	0.00	0.00	0.00	0.02	0.49	0.96	1.32	1.41	1.46	1.50	1.56	1.60	1.66	1.69	1.72	1.74
2.11	0.00	0.00	0.00	0.01	0.46	0.92	1.28	1.36	1.42	1.46	1.52	1.56	1.61	1.64	1.68	1.70
2.12	0.00	0.00	0.00	0.00	0.43	0.88	1.24	1.32	1.38	1.42	1.48	1.52	1.57	1.60	1.64	1.66
2.13	0.00	0.00	0.00	0.00	0.40	0.85	1.20	1.28	1.34	1.38	1.44	1.48	1.53	1.56	1.60	1.62
2.14	0.00	0.00	0.00	0.00	0.36	0.81	1.16	1.25	1.30	1.34	1.40	1.44	1.49	1.52	1.56	1.58
2.15	0.00	0.00	0.00	0.00	0.35	0.78	1.13	1.21	1.26	1.30	1.36	1.40	1.45	1.48	1.52	1.54
2.16	0.00	0.00	0.00	0.00	0.32	0.75	1.09	1.17	1.22	1.26	1.32	1.36	1.41	1.44	1.48	1.50
2.17	0.00	0.00	0.00	0.00	0.30	0.71	1.06	1.13	1.18	1.22	1.29	1.32	1.38	1.41	1.44	1.46
2.18	0.00	0.00	0.00	0.00	0.28	0.68	1.02	1.10	1.15	1.19	1.25	1.28	1.34	1.37	1.40	1.41
2.19	0.00	0.00	0.00	0.00	0.26	0.65	0.99	1.06	1.11	1.15	1.22	1.25	1.30	1.33	1.37	1.39
2.20	0.000	0.000	0.000	0.000	0.236	0.625	0.954	1.030	1.083	1.122	1.178	1.214	1.267	1.299	1.330	1.346
2.21	0.000	0.000	0.000	0.000	0.217	0.597	0.922	0.997	1.050	1.089	1.144	1.180	1.233	1.265	1.295	1.311
2.22	0.000	0.000	0.000	0.000	0.199	0.570	0.891	0.966	1.018	1.056	1.111	1.147	1.199	1.231	1.261	1.277
2.23	0.000	0.000	0.000	0.000	0.182	0.544	0.861	0.935	0.986	1.025	1.079	1.115	1.167	1.197	1.228	1.244
2.24	0.000	0.000	0.000	0.000	0.166	0.519	0.831	0.905	0.956	0.994	1.048	1.083	1.135	1.165	1.195	1.211
2.25	0.000	0.000	0.000	0.000	0.150	0.495	0.802	0.875	0.926	0.964	1.018	1.052	1.104	1.134	1.163	1.179
2.26	0.000	0.000	0.000	0.000	0.136	0.471	0.775	0.847	0.897	0.935	0.987	1.022	1.073	1.103	1.132	1.148
2.27	0.000	0.000	0.000	0.000	0.123	0.449	0.748	0.819	0.869	0.906	0.958	0.993	1.043	1.073	1.103	1.118
2.28	0.000	0.000	0.000	0.000	0.111	0.427	0.722	0.792	0.841	0.878	0.930	0.964	1.014	1.044	1.073	1.088
2.29	0.000	0.000	0.000	0.000	0.099	0.406	0.697	0.766	0.814	0.851	0.902	0.936	0.986	1.015	1.044	1.059

Q_U or Q_L	Sample Size 3	4	5	7	10	15	25	30	35	40	50	60	85	115	175	230
2.30	0.000	0.000	0.000	0.000	0.089	0.386	0.672	0.741	0.789	0.825	0.875	0.909	0.959	0.988	1.016	1.031
2.31	0.000	0.000	0.000	0.000	0.079	0.367	0.648	0.716	0.763	0.799	0.849	0.882	0.931	0.960	0.988	1.003
2.32	0.000	0.000	0.000	0.000	0.070	0.348	0.624	0.691	0.739	0.774	0.823	0.856	0.905	0.934	0.962	0.976
2.33	0.000	0.000	0.000	0.000	0.061	0.330	0.601	0.668	0.715	0.750	0.798	0.831	0.879	0.908	0.935	0.950
2.34	0.000	0.000	0.000	0.000	0.054	0.313	0.579	0.645	0.691	0.720	0.774	0.807	0.854	0.882	0.909	0.924
2.35	0.000	0.000	0.000	0.000	0.047	0.296	0.558	0.623	0.669	0.703	0.750	0.782	0.829	0.877	0.884	0.899
2.36	0.000	0.000	0.000	0.000	0.040	0.280	0.538	0.602	0.646	0.680	0.728	0.759	0.806	0.833	0.860	0.874
2.37	0.000	0.000	0.000	0.000	0.035	0.265	0.518	0.580	0.624	0.658	0.705	0.736	0.782	0.809	0.836	0.850
2.38	0.000	0.000	0.000	0.000	0.029	0.250	0.498	0.560	0.604	0.637	0.683	0.714	0.759	0.787	0.813	0.827
2.39	0.000	0.000	0.000	0.000	0.025	0.236	0.479	0.541	0.584	0.616	0.662	0.693	0.737	0.764	0.791	0.804
2.40	0.000	0.000	0.000	0.000	0.021	0.223	0.461	0.521	0.564	0.596	0.641	0.671	0.715	0.742	0.769	0.782
2.41	0.000	0.000	0.000	0.000	0.017	0.210	0.443	0.503	0.545	0.577	0.621	0.651	0.695	0.721	0.747	0.760
2.42	0.000	0.000	0.000	0.000	0.014	0.198	0.426	0.485	0.526	0.557	0.601	0.631	0.674	0.701	0.726	0.739
2.43	0.000	0.000	0.000	0.000	0.011	0.186	0.410	0.467	0.508	0.539	0.582	0.611	0.654	0.679	0.706	0.718
2.44	0.000	0.000	0.000	0.000	0.009	0.175	0.393	0.450	0.491	0.521	0.564	0.593	0.635	0.660	0.685	0.698
2.45	0.000	0.000	0.000	0.000	0.007	0.165	0.378	0.434	0.473	0.503	0.545	0.573	0.616	0.641	0.665	0.678
2.46	0.000	0.000	0.000	0.000	0.005	0.154	0.362	0.417	0.456	0.486	0.528	0.556	0.597	0.622	0.646	0.659
2.47	0.000	0.000	0.000	0.000	0.004	0.145	0.348	0.403	0.441	0.470	0.511	0.538	0.579	0.604	0.627	0.640
2.48	0.000	0.000	0.000	0.000	0.003	0.136	0.333	0.387	0.425	0.454	0.494	0.522	0.562	0.586	0.609	0.622
2.49	0.000	0.000	0.000	0.000	0.002	0.127	0.321	0.372	0.409	0.438	0.478	0.504	0.545	0.569	0.593	0.605
2.50	0.000	0.000	0.000	0.000	0.001	0.118	0.307	0.358	0.395	0.423	0.463	0.489	0.528	0.552	0.575	0.587
2.51	0.000	0.000	0.000	0.000	0.001	0.111	0.294	0.345	0.381	0.409	0.447	0.473	0.512	0.536	0.558	0.570
2.52	0.000	0.000	0.000	0.000	0.000	0.103	0.282	0.331	0.367	0.394	0.432	0.458	0.497	0.519	0.542	0.553
2.53	0.000	0.000	0.000	0.000	0.000	0.096	0.270	0.319	0.354	0.381	0.418	0.444	0.481	0.503	0.526	0.537
2.54	0.000	0.000	0.000	0.000	0.000	0.089	0.258	0.306	0.340	0.367	0.404	0.428	0.466	0.488	0.510	0.522
2.55	0.000	0.000	0.000	0.000	0.000	0.083	0.247	0.294	0.328	0.354	0.390	0.415	0.451	0.473	0.495	0.506
2.56	0.000	0.000	0.000	0.000	0.000	0.077	0.237	0.283	0.316	0.341	0.377	0.401	0.437	0.459	0.480	0.491
2.57	0.000	0.000	0.000	0.000	0.000	0.071	0.227	0.272	0.304	0.328	0.364	0.388	0.424	0.445	0.466	0.477
2.58	0.000	0.000	0.000	0.000	0.000	0.066	0.217	0.261	0.292	0.317	0.352	0.376	0.411	0.432	0.452	0.463
2.59	0.000	0.000	0.000	0.000	0.000	0.061	0.207	0.251	0.282	0.305	0.340	0.363	0.397	0.418	0.439	0.449
2.60	0.000	0.000	0.000	0.000	0.000	0.056	0.198	0.240	0.271	0.294	0.328	0.351	0.385	0.406	0.426	0.436
2.61	0.000	0.000	0.000	0.000	0.000	0.052	0.189	0.231	0.260	0.283	0.317	0.339	0.372	0.393	0.413	0.423
2.62	0.000	0.000	0.000	0.000	0.000	0.048	0.181	0.221	0.250	0.273	0.306	0.327	0.360	0.381	0.400	0.410
2.63	0.000	0.000	0.000	0.000	0.000	0.044	0.173	0.212	0.241	0.263	0.295	0.316	0.349	0.368	0.388	0.398
2.64	0.000	0.000	0.000	0.000	0.000	0.040	0.164	0.203	0.232	0.253	0.285	0.306	0.338	0.357	0.376	0.386
2.65	0.000	0.000	0.000	0.000	0.000	0.037	0.157	0.195	0.223	0.244	0.274	0.295	0.327	0.346	0.365	0.375
2.66	0.000	0.000	0.000	0.000	0.000	0.034	0.149	0.186	0.213	0.234	0.265	0.285	0.316	0.335	0.353	0.363
2.67	0.000	0.000	0.000	0.000	0.000	0.031	0.143	0.179	0.205	0.225	0.255	0.275	0.305	0.324	0.342	0.352
2.68	0.000	0.000	0.000	0.000	0.000	0.028	0.136	0.171	0.197	0.217	0.246	0.266	0.296	0.314	0.332	0.342
2.69	0.000	0.000	0.000	0.000	0.000	0.025	0.129	0.164	0.190	0.209	0.238	0.257	0.286	0.304	0.321	0.331

TABLE C-5—Continued

Table for Estimating the Lot Percent Defective Using Range Method

Q_U or Q_L	Sample Size															
	3	4	5	7	10	15	25	30	35	40	50	60	85	115	175	230
2.70	0.000	0.000	0.000	0.000	0.000	0.023	0.123	0.156	0.182	0.201	0.228	0.248	0.277	0.295	0.311	0.321
2.71	0.000	0.000	0.000	0.000	0.000	0.021	0.117	0.150	0.174	0.193	0.220	0.239	0.267	0.285	0.302	0.311
2.72	0.000	0.000	0.000	0.000	0.000	0.019	0.111	0.143	0.167	0.185	0.212	0.231	0.259	0.275	0.292	0.301
2.73	0.000	0.000	0.000	0.000	0.000	0.017	0.106	0.137	0.160	0.178	0.205	0.222	0.250	0.266	0.283	0.292
2.74	0.000	0.000	0.000	0.000	0.000	0.015	0.101	0.131	0.153	0.171	0.197	0.215	0.241	0.258	0.274	0.282
2.75	0.000	0.000	0.000	0.000	0.000	0.014	0.096	0.125	0.147	0.164	0.189	0.207	0.233	0.248	0.266	0.274
2.76	0.000	0.000	0.000	0.000	0.000	0.012	0.091	0.120	0.141	0.158	0.182	0.200	0.225	0.241	0.257	0.265
2.77	0.000	0.000	0.000	0.000	0.000	0.011	0.086	0.114	0.135	0.152	0.175	0.192	0.217	0.232	0.249	0.257
2.78	0.000	0.000	0.000	0.000	0.000	0.010	0.081	0.109	0.130	0.146	0.169	0.185	0.210	0.226	0.241	0.249
2.79	0.000	0.000	0.000	0.000	0.000	0.008	0.077	0.103	0.124	0.140	0.163	0.179	0.202	0.218	0.233	0.241
2.80	0.000	0.000	0.000	0.000	0.000	0.007	0.074	0.099	0.118	0.134	0.156	0.172	0.196	0.210	0.225	0.233
2.81	0.000	0.000	0.000	0.000	0.000	0.007	0.070	0.094	0.113	0.129	0.150	0.165	0.189	0.204	0.218	0.226
2.82	0.000	0.000	0.000	0.000	0.000	0.006	0.066	0.090	0.109	0.123	0.144	0.159	0.183	0.194	0.211	0.219
2.83	0.000	0.000	0.000	0.000	0.000	0.005	0.062	0.085	0.103	0.118	0.139	0.154	0.176	0.190	0.204	0.212
2.84	0.000	0.000	0.000	0.000	0.000	0.004	0.059	0.082	0.099	0.113	0.134	0.148	0.170	0.184	0.197	0.205
2.85	0.000	0.000	0.000	0.000	0.000	0.004	0.055	0.078	0.095	0.109	0.128	0.143	0.164	0.178	0.191	0.198
2.86	0.000	0.000	0.000	0.000	0.000	0.003	0.053	0.074	0.091	0.104	0.124	0.137	0.159	0.172	0.185	0.192
2.87	0.000	0.000	0.000	0.000	0.000	0.003	0.050	0.070	0.087	0.100	0.119	0.132	0.152	0.166	0.179	0.185
2.88	0.000	0.000	0.000	0.000	0.000	0.002	0.047	0.067	0.082	0.095	0.114	0.127	0.147	0.160	0.173	0.179
2.89	0.000	0.000	0.000	0.000	0.000	0.002	0.044	0.064	0.079	0.091	0.109	0.122	0.142	0.155	0.167	0.173
2.90	0.000	0.000	0.000	0.000	0.000	0.002	0.042	0.061	0.075	0.088	0.105	0.117	0.138	0.149	0.161	0.168
2.91	0.000	0.000	0.000	0.000	0.000	0.001	0.039	0.057	0.072	0.084	0.101	0.112	0.132	0.145	0.156	0.162
2.92	0.000	0.000	0.000	0.000	0.000	0.001	0.037	0.055	0.069	0.080	0.097	0.107	0.127	0.140	0.151	0.157
2.93	0.000	0.000	0.000	0.000	0.000	0.001	0.035	0.052	0.066	0.077	0.093	0.106	0.123	0.134	0.146	0.151
2.94	0.000	0.000	0.000	0.000	0.000	0.001	0.033	0.049	0.062	0.073	0.089	0.100	0.118	0.129	0.141	0.146
2.95	0.000	0.000	0.000	0.000	0.000	0.001	0.031	0.047	0.059	0.070	0.086	0.096	0.114	0.125	0.136	0.142
2.96	0.000	0.000	0.000	0.000	0.000	0.001	0.029	0.044	0.056	0.067	0.082	0.092	0.110	0.121	0.132	0.137
2.97	0.000	0.000	0.000	0.000	0.000	0.000	0.027	0.042	0.054	0.064	0.079	0.088	0.105	0.116	0.127	0.132
2.98	0.000	0.000	0.000	0.000	0.000	0.000	0.025	0.039	0.051	0.061	0.075	0.085	0.101	0.112	0.123	0.128
2.99	0.000	0.000	0.000	0.000	0.000	0.000	0.024	0.038	0.049	0.058	0.072	0.082	0.098	0.108	0.119	0.124
3.00	0.000	0.000	0.000	0.000	0.000	0.000	0.022	0.036	0.047	0.056	0.069	0.078	0.094	0.105	0.115	0.120
3.01	0.000	0.000	0.000	0.000	0.000	0.000	0.022	0.034	0.044	0.053	0.066	0.075	0.091	0.101	0.111	0.116
3.02	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.032	0.042	0.050	0.063	0.072	0.087	0.097	0.107	0.112
3.03	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.030	0.040	0.048	0.061	0.069	0.084	0.094	0.103	0.108
3.04	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.028	0.038	0.045	0.058	0.066	0.081	0.090	0.099	0.104
3.05	0.000	0.000	0.000	0.000	0.000	0.000	0.016	0.027	0.036	0.043	0.056	0.064	0.078	0.086	0.096	0.101
3.06	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.025	0.034	0.041	0.053	0.061	0.075	0.083	0.092	0.097
3.07	0.000	0.000	0.000	0.000	0.000	0.000	0.014	0.024	0.032	0.039	0.051	0.059	0.072	0.080	0.089	0.094
3.08	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.022	0.030	0.037	0.049	0.056	0.069	0.077	0.086	0.091
3.09	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.021	0.029	0.036	0.046	0.054	0.067	0.075	0.083	0.088

Q_U or Q_L	Sample Size															
	3	4	5	7	10	15	25	30	35	40	50	60	85	115	175	230
3.10	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.020	0.027	0.034	0.044	0.051	0.064	0.072	0.080	0.085
3.11	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.019	0.026	0.032	0.042	0.050	0.061	0.069	0.077	0.082
3.12	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.018	0.025	0.031	0.041	0.048	0.060	0.067	0.074	0.079
3.13	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.017	0.024	0.029	0.039	0.046	0.057	0.064	0.072	0.075
3.14	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.015	0.022	0.028	0.037	0.044	0.055	0.062	0.069	0.073
3.15	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.014	0.021	0.026	0.036	0.042	0.053	0.060	0.067	0.070
3.16	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.014	0.020	0.025	0.034	0.040	0.051	0.057	0.064	0.067
3.17	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.013	0.019	0.024	0.033	0.038	0.049	0.056	0.062	0.065
3.18	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.012	0.017	0.022	0.031	0.036	0.046	0.053	0.060	0.063
3.19	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.012	0.017	0.021	0.030	0.034	0.044	0.052	0.057	0.060
3.20	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.011	0.016	0.020	0.028	0.033	0.043	0.049	0.055	0.058
3.21	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.010	0.015	0.019	0.027	0.032	0.041	0.047	0.053	0.056
3.22	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.009	0.014	0.018	0.025	0.031	0.040	0.045	0.051	0.054
3.23	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.009	0.013	0.017	0.024	0.029	0.037	0.043	0.049	0.052
3.24	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.009	0.013	0.016	0.023	0.028	0.037	0.042	0.047	0.050
3.25	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.008	0.012	0.015	0.022	0.027	0.033	0.040	0.046	0.049
3.26	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.007	0.011	0.015	0.021	0.025	0.033	0.039	0.044	0.047
3.27	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.007	0.011	0.014	0.021	0.024	0.032	0.037	0.042	0.045
3.28	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.006	0.010	0.013	0.019	0.023	0.031	0.036	0.040	0.043
3.29	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.006	0.009	0.012	0.018	0.023	0.029	0.034	0.039	0.042
3.30	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.005	0.009	0.012	0.017	0.021	0.028	0.033	0.037	0.040
3.31	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.005	0.008	0.011	0.017	0.021	0.027	0.032	0.036	0.039
3.32	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.007	0.011	0.016	0.020	0.026	0.030	0.034	0.037
3.33	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.007	0.010	0.015	0.019	0.025	0.029	0.033	0.036
3.34	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.007	0.009	0.014	0.018	0.024	0.028	0.032	0.035
3.35	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.006	0.009	0.014	0.017	0.023	0.027	0.031	0.033
3.36	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.006	0.008	0.013	0.016	0.022	0.026	0.030	0.032
3.37	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.006	0.008	0.012	0.015	0.021	0.024	0.028	0.031
3.38	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.005	0.007	0.012	0.014	0.019	0.024	0.027	0.030
3.39	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.005	0.007	0.011	0.014	0.019	0.022	0.027	0.029
3.40	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.005	0.007	0.010	0.013	0.018	0.021	0.026	0.027
3.41	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.004	0.006	0.010	0.012	0.018	0.021	0.025	0.027
3.42	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.004	0.006	0.009	0.012	0.017	0.020	0.024	0.026
3.43	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.004	0.005	0.009	0.011	0.016	0.019	0.023	0.025
3.44	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.004	0.005	0.008	0.011	0.015	0.018	0.022	0.024
3.45	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.004	0.005	0.008	0.011	0.014	0.017	0.021	0.023
3.46	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.005	0.008	0.010	0.014	0.017	0.020	0.022
3.47	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.007	0.010	0.014	0.016	0.019	0.021
3.48	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.007	0.009	0.013	0.015	0.018	0.020
3.49	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.004	0.006	0.009	0.012	0.015	0.018	0.020

TABLE C-5—Continued

Table for Estimating the Lot Percent Defective Using Range Method

Q_U or Q_L	Sample Size															
	3	4	5	7	10	15	25	30	35	40	50	60	85	115	175	230
3.50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.006	0.008	0.012	0.014	0.017	0.019
3.51	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.006	0.008	0.011	0.014	0.016	0.018
3.52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.006	0.007	0.010	0.013	0.016	0.017
3.53	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.005	0.007	0.010	0.013	0.015	0.016
3.54	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.007	0.010	0.012	0.014	0.015
3.55	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.006	0.009	0.012	0.014	0.015
3.56	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.004	0.006	0.009	0.011	0.013	0.014
3.57	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.004	0.005	0.008	0.011	0.012	0.013
3.58	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.005	0.008	0.010	0.012	0.013
3.59	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.005	0.008	0.010	0.011	0.012
3.60	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.005	0.007	0.009	0.011	0.012
3.61	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.004	0.007	0.009	0.011	0.011
3.62	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.004	0.007	0.009	0.010	0.011
3.63	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.003	0.004	0.006	0.008	0.010	0.010
3.64	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.003	0.003	0.006	0.008	0.009	0.010
3.65	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.003	0.003	0.006	0.008	0.009	0.010
3.66	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.003	0.005	0.007	0.009	0.009
3.67	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.003	0.005	0.007	0.008	0.009
3.68	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.005	0.006	0.008	0.008
3.69	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.002	0.004	0.006	0.008	0.008

Q_U or Q_L	Sample Size															
	3	4	5	7	10	15	25	30	35	40	50	60	85	115	175	230
3.70	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.002	0.004	0.006	0.007	0.008
3.71	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.004	0.006	0.007	0.007
3.72	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.004	0.006	0.007	0.007
3.73	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.004	0.006	0.007	0.007
3.74	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.004	0.005	0.006	0.007
3.75	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.005	0.006	0.006
3.76	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.005	0.006	0.006
3.77	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.005	0.006	0.006
3.78	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.005	0.005
3.79	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.003	0.005	0.005
3.80	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.003	0.005	0.005
3.81	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.003	0.005	0.005
3.82	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.003	0.005	0.005
3.83	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.003	0.004	0.004
3.84	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.004	0.004
3.85	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.004	0.004
3.86	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.004	0.004
3.87	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.004	0.004
3.88	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.004	0.004
3.89	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.003
3.90	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.003

Part III

ESTIMATION OF PROCESS AVERAGE AND CRITERIA FOR REDUCED AND TIGHTENED INSPECTION

C13. ESTIMATION OF PROCESS AVERAGE

The average percent defective, based upon a group of lots submitted for original inspection, is called the process average. Original inspection is the first inspection of a particular quantity of product submitted for acceptability as distinguished from the inspection of product which has been resubmitted after prior rejection. The process average shall be estimated from the results of inspection of samples drawn from a specified number of preceding lots for the purpose of determining severity of inspection during the course of a contract in accordance with paragraph C14.3. Any lot shall be included only once in estimating the process average. The estimate of the process average is designated by $\bar{p}_U$ when computed with respect to an upper specification limit, by $\bar{p}_L$ when computed with respect to a lower specification limit, and by $\bar{p}$ when computed with respect to a double specification limit.

C13.1 Abnormal Results. The results of inspection of product manufactured under conditions not typical of usual production shall be excluded from the estimated process average.

C13.2 Computation of the Estimated Process Average. The estimated process average is the arithmetic mean of the estimated lot percent defectives computed from the sampling inspection results of the preceding ten (10) lots or as may be otherwise designated. In order to estimate the lot percent defective, the quality indices Q_U and/or Q_L shall be computed for each lot. These are: $Q_U = (U-\bar{X})c/\bar{R}$ and $Q_L = (\bar{X}-L)c/\bar{R}$. (See paragraph C11.2.)

C13.2.1 Single Specification Limit.[6] The estimated lot percent defective shall be determined from Table C-5 for the plans based on the range method. The quality index Q_U shall be used for the case of an upper specification limit or Q_L for the case of a lower specification limit. Table C-5 is entered with Q_U or Q_L and the sample size, and the corresponding estimated lot percent defective p_U or p_L, respectively, is read from the table. The estimated process average $\bar{p}_U$ is the arithmetic mean of the individual estimated lot percent defectives p_U's. Similarly, the estimated process average $\bar{p}_L$ is the arithmetic mean of the individual estimated lot percent defectives p_L's.

C13.2.2 Double Specification Limit. The estimated lot percent defective shall be determined from Table C-5 for the plans based on the range method. The quality indices Q_U and Q_L shall be computed. Table C-5 is entered separately with Q_U and Q_L and the sample size, and the corresponding p_U and p_L are read from the table. The estimated lot percent defective is $p = p_U + p_L$. The estimated process average $\bar{p}$ is the arithmetic mean of the individual estimated lot percent defectives p's.

C13.2.3 Special Case. If the quality index Q_U or Q_L is a negative number, then Table C-5 is entered by disregarding the negative sign. However, in this case the estimated lot percent defective above the upper limit or below the lower limit is obtained by subtracting the percentage found in the table from 100%.[7]

C14. NORMAL, TIGHTENED, AND REDUCED INSPECTION

This Standard established sampling plans for normal, tightened, and reduced inspection.

C14.1 At Start of Inspection. Normal inspection shall be used at the start of inspection unless otherwise designated.

C14.2 During Inspection. During the course of inspection, normal inspection shall be used when inspection conditions are such that tightened or reduced inspection is not required in accordance with paragraphs C14.3 and C14.4.

C14.3 Tightened Inspection. Tightened inspection shall be instituted when the estimated process average computed from the

[6] When Form 1 – Single Specification Limit is used for the acceptability criterion, the estimate of lot percent defective p_U or p_L is not obtained; in order to estimate the process average, it is necessary to complete paragraphs C6.2 and C6.3 of Form 2.

[7] For example, if $Q_U = -.50$ and $Q_L = 1.60$, using sample size 60, $p_U = 100\% - 30.94\% = 69.06\%$, $p_L = 5.32\%$ and $p = 69.06\% + 5.32\% = 74.38\%$.

preceding ten (10) lots (or such other number of lots designated) in accordance with paragraph C13.2 is greater than the AQL, and when more than a certain number T of these lots have estimates of the percent defective exceeding the AQL. The T-values are given in Table C-6 for the process average computed from 5, 10 or 15 lots.[8] Normal inspection shall be reinstated if the estimated process average of lots under tightened inspection is equal to or less than the AQL.

C14.4 Reduced Inspection. Reduced inspection may be instituted provided that all of the following conditions are satisfied:

Condition A. The preceding ten (10) lots (or such other number of lots designated) have been under normal inspection and none has been rejected.

Condition B. The estimated percent defective for each of these preceding lots is less than the applicable lower limit shown in Table C-7; or for certain sampling plans, the estimated lot percent defective is equal to zero for a specified number of consecutive lots (see Table C-7).

Condition C. Production is at a steady rate.

Normal inspection shall be reinstated if any one of the following conditions occurs under reduced inspection.

Condition D. A lot is rejected.

Condition E. The estimated process average is greater than the AQL.

Condition F. Production becomes irregular or delayed.

Condition G. Other conditions as may warrant that normal inspection should be reinstated.

C14.5 Sampling Plans for Tightened or Reduced Inspection. Sampling plans for tightened and reduced inspection are provided in Section C, Parts I and II.

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[8]If the sample size code letter is not the same for all samples used, the entry in Table C-6 is determined by the sample size code letter corresponding to the smallest sample size used in any of the lots included in the estimation of the process average.

TABLE C-6 — Range Method

Values of T for Tightened Inspection

Sample size code letter	.04	.065	.10	.15	.25	.40	.65	1.0	1.5	2.5	4.0	6.5	10.0	15.0	Number of Lots
	Acceptable Quality Levels (in percent defective)														
B	*	*	*	*	*	*	*	*	*	2	3	4	4	4	5
										4	5	6	7	8	10
										5	6	8	9	11	15
C	*	*	*	*	*	*	*	2	2	3	3	4	4	4	5
								3	4	5	6	7	7	8	10
								5	6	7	8	9	10	11	15
D	*	*	*	*	*	*	2	3	3	3	4	4	4	4	5
							4	4	5	6	6	7	7	8	10
							5	6	7	8	9	10	10	11	15
E	*	*	*	*	2	2	3	3	3	4	4	4	4	4	5
					3	4	4	5	5	6	7	7	7	8	10
					4	5	6	6	7	8	9	10	10	11	15
F	*	*	*	2	3	3	3	3	4	4	4	4	4	4	5
				4	4	5	5	5	6	6	7	7	8	8	10
				5	5	6	7	7	8	9	9	10	11	11	15
G	2	2	3	3	3	3	4	4	4	4	4	4	4	4	5
	4	4	4	5	5	5	6	6	6	7	7	8	8	8	10
	5	5	6	6	7	7	8	8	9	9	10	11	11	11	15
H	3	3	3	3	4	4	4	4	4	4	4	4	4	4	5
	5	5	5	6	6	6	7	7	7	7	7	8	8	8	10
	6	7	7	7	8	8	9	9	10	10	11	11	11	11	15
I	3	3	3	4	4	4	4	4	4	4	4	4	4	4	5
	5	5	6	6	6	6	7	7	7	7	8	8	8	8	10
	7	7	7	8	8	9	9	9	10	10	11	11	11	11	15
J	3	3	4	4	4	4	4	4	4	4	4	4	4	4	5
	5	6	6	6	6	7	7	7	7	7	8	8	8	8	10
	7	7	8	8	9	9	9	10	10	10	11	11	11	11	15
K	3	4	4	4	4	4	4	4	4	4	4	4	4	4	5
	6	6	6	6	7	7	7	7	7	8	8	8	8	8	10
	7	8	8	8	9	9	10	10	10	11	11	11	11	11	15
L	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5
	6	6	6	6	7	7	7	7	7	8	8	8	8	8	10
	8	8	9	9	9	9	10	10	10	11	11	11	11	11	15
M	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5
	6	6	7	7	7	7	7	7	8	8	8	8	8	8	10
	8	9	9	9	9	10	10	10	11	11	11	11	11	11	15
N	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5
	7	7	7	7	7	7	7	8	8	8	8	8	8	8	10
	9	9	9	10	10	10	10	11	11	11	11	11	11	11	15
O	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5
	7	7	7	7	7	7	8	8	8	8	8	8	8	8	10
	9	10	10	10	10	10	11	11	11	11	11	11	11	11	15

*There are no sampling plans provided in this Standard for these code letters and AQL values.

Range Method

TABLE C-6—Continued

Values of T for Tightened Inspection

Sample size code letter	Acceptable Quality Levels (in percent defective)														Number of Lots
	.04	.065	.10	.15	.25	.40	.65	1.0	1.5	2.5	4.0	6.5	10.0	15.0	
P	4 7 10	4 7 10	4 7 10	4 7 10	4 7 10	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 12	5 10 15
Q	4 7 10	4 7 10	4 7 10	4 8 10	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 12	5 10 15

The top figure in each block refers to the preceding 5 lots, the middle figure to the preceding 10 lots and the bottom figure to the preceding 15 lots.

Tightened inspection is required when the number of lots with estimates of percent defective above the AQL from the preceding 5, 10, *or* 15 lots is greater than the given value of T in the table, and the process average from these lots exceeds the AQL.

All estimates of the lot percent defective are obtained from Table C-5.

Range Method

TABLE C-7

Limits of Estimated Lot Percent Defective for Reduced Inspection

Sample size code letter	Acceptable Quality Levels														Number of Lots
	.04	.065	.10	.15	.25	.40	.65	1.0	1.5	2.5	4.0	6.5	10.0	15.0	
B	*	*	*	*	*	*	*	*	*	[42]**	[28]**	[18]**	[12]**	[9]**	
C	*	*	*	*	*	*	*	[45]**	[31]**	[22]**	[15]**	[10]**	[7]**	.77 15.00 ▲	5 10 15
D	*	*	*	*	*	*	[33]**	[25]**	[18]**	[13]**	[9]**	0.00 4.40 6.50	.74 9.96 10.00	6.06 15.00 ▲	5 10 15
E	*	*	*	*	[30]**	[23]**	[17]**	[13]**	[10]**	.00 .35 1.84	0.00 1.84 4.00	.79 5.74 6.50	3.52 10.00 ▲	8.45 15.00 ▲	5 10 15
F	*	*	*	[19]**	[14]**	[11]**	.000 .008 .158	.000 .104 .50	.00 .40 1.14	.061 1.32 2.50	.53 3.01 4.00	2.04 6.06 6.50	4.92 10.00 ▲	9.66 15.00 ▲	5 10 15
G	[12]**	[10]**	[8]**	.000 .002 .020	.000 .015 .074	.000 .060 .199	.006 .192 .466	.040 .449 .90	.148 .90 1.50	.536 1.94 2.50	1.41 3.63 4.00	3.27 6.50 ▲	6.30 10.00 ▲	11.01 15.00 ▲	5 10 15
H	.000 .003 .011	.000 .009 .025	.002 .020 .052	.004 .042 .096	.014 .101 .199	.042 .209 .374	.112 .422 .65	.248 .755 1.00	.498 1.26 1.50	1.12 2.34 2.50	2.20 4.00 ▲	4.27 6.50 ▲	7.40 10.00 ▲	12.13 15.00 ▲	5 10 15
I	.001 .006 .017	.002 .015 .037	.004 .032 .067	.010 .061 .118	.028 .130 .230	.069 .252 .40	.162 .478 .65	.326 .822 1.00	.608 1.34 1.50	1.27 2.42 2.50	2.42 4.00 ▲	4.52 6.50 ▲	7.68 10.00 ▲	12.43 15.00 ▲	5 10 15
J	.001 .010 .022	.004 .021 .044	.007 .042 .079	.017 .075 .133	.042 .151 .248	.094 .281 .40	.202 .516 .65	.386 .867 1.00	.691 1.39 1.50	1.39 2.47 2.50	2.57 4.00 ▲	4.71 6.50 ▲	7.91 10.00 ▲	12.65 15.00 ▲	5 10 15

*There are no sampling plans provided in this Standard for these code letters and AQL values.

Range Method

TABLE C-7—Continued

Limits of Estimated Lot Percent Defective for Reduced Inspection

Sample size code letter	Acceptable Quality Levels														Number of Lots
	.04	.065	.10	.15	.25	.40	.65	1.0	1.5	2.5	4.0	6.5	10.0	15.0	
K	.002	.005	.012	.024	.056	.114	.235	.435	.758	1.48	2.69	4.86	8.06	12.82	5
	.013	.027	.049	.087	.167	.302	.544	.899	1.43	2.50	4.00	6.50	10.00	15.00	10
	.026	.050	.088	.144	.25	.40	.65	1.00	1.50	▲	▲	▲	▲	▲	15
L	.004	.010	.020	.036	.076	.148	.288	.509	.857	1.62	2.86	5.07	8.31	13.09	5
	.018	.036	.062	.102	.190	.332	.581	.942	1.47	2.50	4.00	6.50	10.00	15.00	10
	.033	.059	.099	.15	.25	.40	.65	1.00	1.50	▲	▲	▲	▲	▲	15
M	.007	.014	.026	.046	.092	.174	.326	.562	.927	1.72	2.99	5.22	8.48	13.27	5
	.023	.041	.069	.112	.206	.352	.604	.968	1.50	2.50	4.00	6.50	10.00	15.00	10
	.036	.064	.10	.15	.25	.40	.65	1.00	▲	▲	▲	▲	▲	▲	15
N	.012	.022	.038	.064	.122	.216	.389	.648	1.041	1.87	3.19	5.46	8.76	13.57	5
	.028	.051	.082	.129	.226	.378	.636	1.00	1.50	2.50	4.00	6.50	10.00	15.00	10
	.042	.065	.10	.15	.25	.40	.65	▲	▲	▲	▲	▲	▲	▲	15
O	.015	.029	.048	.078	.144	.246	.434	.709	1.119	1.98	3.32	5.63	8.95	13.79	5
	.033	.056	.089	.139	.238	.393	.65	1.00	1.50	2.50	4.00	6.50	10.00	15.00	10
	.04	.065	.10	.15	.25	.40	▲	▲	▲	▲	▲	▲	▲	▲	15
P	.021	.036	.059	.093	.166	.280	.480	.771	1.199	2.08	3.46	5.80	9.15	14.02	5
	.036	.061	.095	.146	.248	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00	15.00	10
	.04	.065	.10	.15	.25	▲	▲	▲	▲	▲	▲	▲	▲	▲	15
Q	.024	.040	.065	.103	.179	.300	.507	.808	1.248	2.15	3.54	5.90	9.27	14.15	5
	.038	.063	.099	.149	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00	15.00	10
	.04	.065	.10	.15	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	15

All AQL and table values, except those in the brackets, are in percent defective.

▲Use the first figure in direction of arrow and corresponding number of lots. In each block the top figure refers to the preceding 5 lots, the middle figure to the preceding 10 lots, and the bottom figure to the preceding 15 lots.

Reduced inspection may be instituted when every estimated lot percent defective from the preceding 5, 10, or 15 lots is below the figure given in the table; reduced inspection for sampling plans marked (**) in the table requires that the estimated lot percent defective is equal to zero for the number of consecutive lots indicated in brackets. In addition, all other conditions for reduced inspection, in Part III of Section C, must be satisfied.

All estimates of the lot percent defective are obtained from Table C-5.

TABLE C-8

Values of f for Maximum Average Range (MAR)

Sample size code letter	Sample size	Acceptable Quality Levels (in percent defective)													
		.04	.065	.10		.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00	15.00
B	3										.833	.865	.907	.958	1.028
C	4								.756	.788	.836	.891	.965	1.056	1.180
D	5							.730	.764	.801	.857	.923	1.011	1.118	1.263
E	7					.695	.727	.765	.804	.846	.910	.985	1.086	1.209	1.374
F	10				.529	.553	.579	.610	.642	.677	.730	.793	.876	.977	1.112
G	15	.444	.460	.477	.493	.517	.542	.572	.602	.637	.688	.748	.830	.928	1.058
H	25	.416	.432	.447	.463	.486	.509	.537	.567	.600	.649	.707	.785	.879	1.004
I	30	.411	.426	.442	.457	.480	.503	.531	.560	.593	.642	.699	.776	.870	.993
J	35	.408	.423	.438	.454	.476	.499	.527	.556	.588	.637	.694	.771	.864	.987
K	40	.402	.417	.432	.447	.469	.492	.519	.548	.580	.628	.684	.761	.852	.968
L	50	.396	.411	.426	.441	.463	.486	.503	.542	.573	.621	.676	.752	.843	.963
M	60	.390	.405	.419	.434	.455	.478	.505	.533	.564	.608	.666	.740	.830	.949
N	85	.382	.398	.412	.427	.448	.470	.497	.525	.555	.602	.656	.729	.818	.934
O	115	.378	.392	.406	.421	.442	.464	.490	.517	.548	.594	.648	.720	.808	.923
P	175	.371	.384	.399	.413	.434	.455	.481	.508	.538	.584	.637	.708	.794	.908
Q	230	.369	.384	.397	.412	.432	.454	.480	.507	.536	.582	.633	.706	.792	.906

The MAR may be obtained by multiplying the factor f by the difference between the upper specification limit U and lower specification limit L. The formula is MAR = f(U-L). The MAR serves as a guide for the magnitude of the average range of the sample when using plans for the double specification limit case, based on the average range of the sample of unknown variability. The average range of the sample, if it is less than the MAR, helps to insure, but does not guarantee, lot acceptability.

NOTE: There is a corresponding acceptability constant in Table C-1 for each value of f. For reduced inspection, find the acceptability constant of Table C-2 in Table C-1 and use the corresponding value of f.

APPENDIX C

Definitions

Symbol	Read	Definitions
n		Sample size for a single lot.
$\bar{X}$	X bar	Sample mean. Arithmetic mean of sample measurements from a single lot.
R		Range. The difference between the largest and smallest measurements in a subgroup. In this Standard, the subgroup size is 5 except for those plans in which n = 3, 4 or 7, in which case the subgroup is the same as the sample size.
R_1		Range of the first subgroup.
R_2		Range of the second subgroup.
$\bar{R}$	R bar	Average range. The arithmetic mean of the range values of the subgroups of the sample measurements from a single lot.
U		Upper specification limit.
L		Lower specification limit.
k		The acceptability constant given in Tables C-1 and C-2.
c		A factor used in determining the quality index when using the range method. The c values are given in Tables C-3 and C-4.
Q_U	Q sub U	Quality Index for use with Table C-5.
Q_L	Q sub L	Quality Index for use with Table C-5.
p_U	p sub U	Sample estimate of the lot percent defective above U from Table C-5.
p_L	p sub L	Sample estimate of the lot percent defective below L from Table C-5.
p		Total sample estimate of the lot percent defective $p = p_U + p_L$.
M		Maximum allowable percent defective for sample estimates given in Tables C-3 and C-4.
M_U	M sub U	Maximum allowable percent defective above U given in Tables C-3 and C-4. (For use when different AQL values for U and L are specified.)
M_L	M sub L	Maximum allowable percent defective below L given in Tables C-3 and C-4. (For use when different AQL values for U and L are specified.)
$\bar{p}$	p bar	Sample estimate of the process percent defective, i.e., the estimated process average.
$\bar{p}_U$	p bar sub U	The estimated process average for an upper specification limit.
$\bar{p}_L$	p bar sub L	The estimated process average for a lower specification limit.
T		The maximum number of estimated process averages which may exceed the AQL given in Table C-6. (For use in determining application to tightened inspection.)

APPENDIX C—Continued

Definitions

Symbol	Read	Definitions
f		A factor used in determining the Maximum Average Range (MAR). The f values are given in Table C-8.
>	Greater than	Greater than.
<	Less than	Less than.
Σ	Sum of	Sum of.

SECTION D

VARIABILITY KNOWN

Part I

SINGLE SPECIFICATION LIMIT

D1. SAMPLING PLAN FOR SINGLE SPECIFICATION LIMIT

This part of the Standard describes the procedures for use with plans for a single specification limit when variability of the lot with respect to the quality characteristic is known. The acceptability criterion is given in two equivalent forms. These are identified as Form 1 and Form 2.

D1.1 Use of Sampling Plans. To determine whether the lot meets the acceptability criterion with respect to a particular quality characteristic and AQL value, the applicable sampling plan shall be used in accordance with the provisions of Section A, General Description of Sampling Plans, and those in this part of the Standard.

D1.2 Drawing of Samples. All samples shall be drawn in accordance with paragraph A7.2.

D1.3 Determination of Sample Size Code Letter. The sample size code letter shall be selected from Table A-2 in accordance with paragraph A7.1.

D2. SELECTING THE SAMPLING PLAN WHEN FORM 1 IS USED

D2.1 Master Sampling Tables. The master sampling tables for plans based on variability known for a single specification limit are Tables D-1 and D-2. Table D-1 is used for normal and tightened inspection and Table D-2 for reduced inspection.

D2.2 Obtaining Sampling Plan. The sampling plan consists of a sample size and an associated acceptability constant.[1] The sampling plan is obtained from Master Table D-1 and D-2.

D2.2.1 Sample Size. The sample size n is shown in the master table corresponding to each sample size code letter and AQL.

D2.2.2 Acceptability Constant. The acceptability constant k, corresponding to the sample size mentioned in paragraph D2.2.1, is indicated in the column of the master table corresponding to the applicable AQL value. Table D-1 is entered from the top for normal inspection and from the bottom for tightened inspection. Sampling plans for reduced inspection are provided in Table D-2.

D3. LOT-BY-LOT ACCEPTABILITY PROCEDURES WHEN FORM 1 IS USED[2]

D3.1 Acceptability Criterion. The degree of conformance of a quality characteristic with respect to a single specification limit shall be judged by the quantity $(U-\bar{X})/\sigma$ or $(\bar{X}-L)/\sigma$.

D3.2 Computation. The following quantity shall be computed: $(U-\bar{X})/\sigma$ or $(\bar{X}-L)/\sigma$, depending on whether the specification limit is an upper or a lower limit, where

U is the upper specification limit,
L is the lower specification limit,
$\bar{X}$ is the sample mean, and
σ is the known variability.

D3.3 Acceptability Criterion. Compare the quantity $(U-\bar{X})/\sigma$ or $(\bar{X}-L)/\sigma$ with the acceptability constant k. If $(U-\bar{X})/\sigma$ or $(\bar{X}-L)/\sigma$ is equal to or greater than k, the lot meets the acceptability criterion; if $(U-\bar{X})/\sigma$ or $(\bar{X}-L)/\sigma$ is less than k or negative, then the lot does not meet the acceptability criterion.

D4. SUMMARY FOR OPERATION OF SAMPLING PLAN WHEN FORM 1 IS USED

The following steps summarize the procedures to be followed:

(1) Determine the sample size code letter from Table A-2 by using the lot size and the inspection level.

[1]See Appendix D for definitions of all symbols used in the sampling plans based on variability known.
[2]See Example D-1 for a complete example of this procedure.

(2) Obtain plan from Master Table D-1 or D-2 by selecting the sample size n and the acceptability constant k.

(3) Select at random the sample of n units from the lot; inspect and record the measurement of the quality characteristic for each unit of the sample.

(4) Compute the sample mean $\bar{X}$, and also compute the quantity $(U-\bar{X})/\sigma$ for an upper specification limit U or the quantity $(\bar{X}-L)/\sigma$ for a lower specification limit L.

(5) If the quantity $(U-\bar{X})/\sigma$ or $(\bar{X}-L)/\sigma$ is equal to or greater than k, the lot meets the acceptability criterion; if $(U-\bar{X})/\sigma$ or $(\bar{X}-L)/\sigma$ is less than k or negative, then the lot does not meet the acceptability criterion.

D5. SELECTING THE SAMPLING PLAN WHEN FORM 2 IS USED

D5.1 Master Sampling Tables. The master sampling tables for plans based on variability known for a single specification limit are Tables D-3 and D-4 of Part II. Table D-3 is used for normal and tightened inspection and Table D-4 for reduced inspection.

D5.2 Obtaining the Sampling Plan. The sampling plan consists of a sample size and an associated maximum allowable percent defective. The sampling plan is obtained from Master Table D-3 or D-4.

D5.2.1 Sample Size. The sample size n is shown in the master table corresponding to each sample size code letter.

D5.2.2 Maximum Allowable Percent Defective. The maximum allowable percent defective M for sample estimates corresponding to the sample size mentioned in paragraph D5.2.1 is indicated in the column of the master table corresponding to the applicable AQL value. Table D-3 is entered from the top for normal inspection and from the bottom for tightened inspection. Sampling plans for reduced inspection are provided in Table D-4.

D6. LOT-BY-LOT ACCEPTABILITY PROCEDURES WHEN FORM 2 IS USED[3]

D6.1 Acceptability Criterion. The degree of conformance of a quality characteristic with respect to a single specification limit shall be judged by the percent of nonconforming product outside the upper or lower specification limit. The percentage of nonconforming product is estimated by entering Table D-5 with the quality index.

D6.2 Computation of Quality Index. The quality index $Q_U = (U-\bar{X})v/\sigma$ shall be computed if the specification limit is an upper limit U, or $Q_L = (\bar{X}-L)v/\sigma$ if it is a lower limit L. The quantities, $\bar{X}$ and σ, are the sample mean and known variability, respectively. The factor v is provided in Tables D-3 and D-4 corresponding to the sample size.

D6.3 Estimate of Percent Defective in Lot. The quality of a lot shall be expressed by p_U, the estimated percent defective in the lot above the upper specification limit, or by p_L, the estimated percent defective below the lower specification limit. The estimated percent defective p_U or p_L is obtained by entering Table D-5 with Q_U or Q_L.

D6.4 Acceptability Criterion. Compare the estimated lot percent defective p_U or p_L with the maximum allowable percent defective M. If p_U or p_L is equal to or less than M, the lot meets the acceptability criterion; if p_U or p_L is greater than M or if Q_U or Q_L is negative, then the lot does not meet the acceptability criterion.

D7. SUMMARY FOR OPERATION OF SAMPLING PLAN WHEN FORM 2 IS USED

The following steps summarize the procedures to be followed:

(1) Determine the sample size code letter from Table A-2 by using the lot size and the inspection level.

(2) Obtain plan from Master Table D-3 or D-4 by selecting the sample size n, the factor v, and the maximum allowable percent defective M.

(3) Select at random the sample of n units from the lot; inspect and record the measurement of the quality characteristic on each unit of the sample.

(4) Compute the sample mean $\bar{X}$.

(5) Compute the quality index $Q_U = (U-\bar{X})v/\sigma$ if an upper specification limit U is specified, or $Q_L = (\bar{X}-L)v/\sigma$ if a lower specification limit L is specified.

(6) Determine the estimated lot percent defective p_U or p_L from Table D-5.

[3] *See Example D-2 for a complete example of this procedure.*

(7) If the estimated lot percent defective p_U or p_L is equal to or less than the maximum allowable percent defective M, the lot meets the acceptability criterion; if p_U or p_L is greater than M or if Q_U or Q_L is negative, then the lot does not meet the acceptability criterion.

EXAMPLE D-1

Example of Calculations

Single Specification Limit—Form 1

Variability Known

Example The specified minimum yield point for certain steel castings is 58,000 psi. A lot of 500 items is submitted for inspection. Inspection Level IV, normal inspection, with AQL = 1.5% is to be used. The variability σ is known to be 3000 psi. From Tables A-2 and D-1 it is seen that a sample of size 10 is required. Suppose the yield points of the sample specimens are:

62,500; 60,500; 68,000; 59,000; 65,500;
62,000; 61,000; 69,000; 58,000; 64,500;

and compliance with the acceptability criterion is to be determined.

Line	Information Needed	Value Obtained	Explanation
1	Sample Size: n	10	
2	Known Variability: σ	3,000	
3	Sum of Measurements: ΣX	630,000	
4	Sample Mean $\bar{X}$: $\Sigma X/n$	63,000	63,000/10
5	Specification Limit (Lower): L	58,000	
6	The Quantity: $(\bar{X}-L)/\sigma$	1.67	(63,000-58,000)/3000
7	Acceptability Constant: k	1.70	See Table D-1
8	Acceptability Criterion: Compare $(\bar{X}-L)/\sigma$ with k	$1.67 < 1.70$	See Para. D3.3

The lot does not meet the acceptability criterion, since $(\bar{X}-L)/\sigma$ is less than k.

NOTE: If a single upper specification limit U is given, then compute the quantity $(U-\bar{X})/\sigma$ in line 6 and compare it with k; the lot meets the acceptability criterion if $(U-\bar{X})/\sigma$ is equal to or greater than k.

EXAMPLE D-2

Example of Calculations

Single Specification Limit—Form 2

Variability Known

Example The specified minimum yield point for certain steel castings is 58,000 psi. A lot of 500 items is submitted for inspection. Inspection Level IV, normal inspection, with AQL = 1.5% is to be used. The variability σ is known to be 3000 psi. From Tables A-2 and D-1 it is seen that a sample of size 10 is required. Suppose the yield points of the sample specimens are:

62,500; 60,500; 68,000; 59,000; 65,500;
62,000; 61,000; 69,000; 58,000; 64,500;

and compliance with the acceptability criterion is to be determined.

Line	Information Needed	Value Obtained	Explanation
1	Sample Size: n	10	
2	Known Variability: σ	3,000	
3	Sum of Measurements: ΣX	630,000	
4	Sample Mean $\bar{X}$: $\Sigma X/n$	63,000	630,000/10
5	Factor: v	1.054	
6	Specification Limit (Lower): L	58,000	
7	Quality Index: $Q_L = (\bar{X}-L)v/\sigma$	1.76	$\frac{(63,000-58,000)1.054}{3,000}$
8	Est. of Lot Percent Def: p_L	3.92%	See Table D-5
9	Max. Allowable Percent Def.: M	3.63%	See Table D-3
10	Acceptability Criterion: Compare p_L with M	3.92% > 3.63%	See Para. D6.4

The lot does not meet the acceptability criterion, since p_L is greater than M.

NOTE: If a single upper specification limit U is given, then compute the quality index $Q_U = (U-\bar{X})v/\sigma$ in line 7 and obtain the estimate of the percent defective p_U. Compare p_U with M; the lot meets the acceptability criterion if p_U is equal to or less than M.

TABLE D-1

Master Table for Normal and Tightened Inspection for Plans Based on Variability Known
(Single Specification Limit—Form 1)

Sample size code letter	Acceptable Quality Levels (normal inspection)													
	.04		.065		.10		.15		.25		.40		.65	
	n	k	n	k	n	k	n	k	n	k	n	k	n	k
B	↓		↓		↓		↓		↓		↓		↓	
C														
D													2	1.58
E									2	1.94	2	1.81	3	1.69
F							3	2.19	3	2.07	3	1.91	4	1.80
G	3	2.58	3	2.49	4	2.39	4	2.30	4	2.14	5	2.05	5	1.88
H	4	2.65	4	2.55	5	2.46	5	2.34	6	2.23	6	2.08	7	1.95
I	5	2.69	6	2.59	6	2.49	6	2.37	7	2.25	8	2.13	8	1.96
J	6	2.72	6	2.58	7	2.50	7	2.38	8	2.26	9	2.13	10	1.99
K	7	2.77	7	2.63	8	2.54	9	2.45	9	2.29	10	2.16	11	2.01
L	8	2.77	8	2.64	9	2.54	10	2.45	11	2.31	12	2.18	13	2.03
M	10	2.83	11	2.72	11	2.59	12	2.49	13	2.35	14	2.21	16	2.07
N	14	2.88	15	2.77	16	2.65	17	2.54	19	2.41	21	2.27	23	2.12
O	19	2.92	20	2.80	22	2.69	23	2.57	25	2.43	27	2.29	30	2.14
P	27	2.96	30	2.84	31	2.72	34	2.62	37	2.47	40	2.33	44	2.17
Q	37	2.97	40	2.85	42	2.73	45	2.62	49	2.48	54	2.34	59	2.18
	.065		.10		.15		.25		.40		.65		1.00	
	Acceptable Quality Levels (tightened inspection)													

All AQL values are in percent defective.

↓ Use first sampling plan below arrow, that is, both sample size as well as k value. When sample size equals or exceeds lot size, every item in the lot must be inspected.

TABLE D-1—Continued

Master Table for Normal and Tightened Inspection for Plans Based on Variability Known
(Single Specification Limit – Form 1)

Sample size code letter	Acceptable Quality Levels (normal inspection)													
	1.00		1.50		2.50		4.00		6.50		10.00		15.00	
	n	k	n	k	n	k	n	k	n	k	n	k	n	k
B	▼		▼		▼		▼		▼		▼		▼	
C	2	1.36	2	1.25	2	1.09	2	.936	3	.755	3	.573	4	.344
D	2	1.42	2	1.33	3	1.17	3	1.01	3	.825	4	.641	4	.429
E	3	1.56	3	1.44	4	1.28	4	1.11	5	.919	5	.728	6	.515
F	4	1.69	4	1.53	5	1.39	5	1.20	6	.991	7	.797	8	.584
G	6	1.78	6	1.62	7	1.45	8	1.28	9	1.07	11	.877	12	.649
H	7	1.80	8	1.68	9	1.49	10	1.31	12	1.11	14	.906	16	.685
I	9	1.83	10	1.70	11	1.51	13	1.34	15	1.13	17	.924	20	.706
J	11	1.86	12	1.72	13	1.53	15	1.35	18	1.15	21	.942	24	.719
K	12	1.88	14	1.75	15	1.56	18	1.38	20	1.17	24	.964	27	.737
L	14	1.89	15	1.75	18	1.57	20	1.38	23	1.17	27	.965	31	.741
M	17	1.93	19	1.79	22	1.61	25	1.42	29	1.21	33	.995	38	.770
N	25	1.97	28	1.84	32	1.65	36	1.46	42	1.24	49	1.03	56	.803
O	33	2.00	36	1.86	42	1.67	48	1.48	55	1.26	64	1.05	75	.819
P	49	2.03	54	1.89	61	1.69	70	1.51	82	1.29	95	1.07	111	.841
Q	65	2.04	71	1.89	81	1.70	93	1.51	109	1.29	127	1.07	147	.845
	1.50		2.50		4.00		6.50		10.00		15.00			
	Acceptable Quality Levels (tightened inspection)													

All AQL values are in percent defective.

▼ Use first sampling plan below arrow, that is, both sample size as well as k value. When sample size equals or exceeds lot size, every item in the lot must be inspected.

TABLE D-2

Master Table for Reduced Inspection for Plans Based on Variability Known
(Single Specification Limit—Form 1)

Sample size code letter	Acceptable Quality Levels													
	.04		.065		.10		.15		.25		.40		.65	
	n	k	n	k	n	k	n	k	n	k	n	k	n	k
B	↓		↓		↓		↓		↓		↓		↓	
C														
D														
E														
F													2	1.36
G											2	1.58	2	1.42
H							2	1.94	2	1.81	3	1.69	3	1.56
I					3	2.19	3	2.07	3	1.91	4	1.80	4	1.69
J					3	2.19	3	2.07	3	1.91	4	1.80	4	1.69
K	3	2.49	4	2.39	4	2.30	4	2.14	5	2.05	5	1.88	6	1.78
L	4	2.55	5	2.46	5	2.34	6	2.23	6	2.08	7	1.95	7	1.80
M	4	2.55	5	2.46	5	2.34	6	2.23	6	2.08	7	1.95	7	1.80
N	6	2.59	6	2.49	6	2.37	7	2.25	8	2.13	8	1.96	9	1.83
O	6	2.58	7	2.50	7	2.38	8	2.26	9	2.13	10	1.99	11	1.86
P	11	2.72	11	2.59	12	2.49	13	2.35	14	2.21	16	2.07	17	1.93
Q	15	2.77	16	2.65	17	2.54	19	2.41	21	2.27	23	2.12	25	1.97

All AQL values are in percent defective.

↓ Use first sampling plan below arrow, that is, both sample size as well as k value. When sample size equals or exceeds lot size, every item in the lot must be inspected.

TABLE D-2—Continued

Master Table for Reduced Inspection for Plans Based on Variability Known
(Single Specification Limit—Form 1)

Sample size code letter	Acceptable Quality Levels											
	1.00		1.50		2.50		4.0		6.5		10.00	
	n	k	n	k	n	k	n	k	n	k	n	k
B	↓		↓		↓		↓		↓		↓	
C												
D												
E												
F	2	1.25	2	1.09	2	.936	3	.755	3	.573	4	.344
G	2	1.33	3	1.17	3	1.01	3	.825	4	.641	4	.429
H	3	1.44	4	1.28	4	1.11	5	.919	5	.728	6	.515
I	4	1.53	5	1.39	5	1.20	6	.991	7	.797	8	.584
J	4	1.53	5	1.39	5	1.20	6	.991	7	.797	8	.584
K	6	1.62	7	1.45	8	1.28	9	1.07	11	.877	12	.649
L	8	1.68	9	1.49	10	1.31	12	1.11	14	.906	16	.685
M	8	1.68	9	1.49	10	1.31	12	1.11	14	.906	16	.685
N	10	1.70	11	1.51	13	1.34	15	1.13	17	.924	20	.706
O	12	1.72	13	1.53	15	1.35	18	1.15	21	.942	24	.719
P	19	1.79	22	1.61	25	1.42	29	1.21	33	.995	38	.770
Q	28	1.84	32	1.65	36	1.46	42	1.24	49	1.03	56	.803

All AQL values are in percent defective.

↓ Use first sampling plan below arrow, that is, both sample size as well as k value. When sample size equals or exceeds lot size, every item in the lot must be inspected.

Part II

DOUBLE SPECIFICATION LIMIT

D8. SAMPLING PLAN FOR DOUBLE SPECIFICATION LIMIT

This part of the Standard describes the procedures for use with plans for a double specification limit when variability of the lot with respect to the quality characteristic is known.

D8.1 Use of Sampling Plans. To determine whether the lot meets the acceptability criterion with respect to a particular quality characteristic and AQL value(s), the applicable sampling plan shall be used in accordance with the provisions of Section A, General Description of Sampling Plans, and those in this part of the Standard.

D9. SELECTING THE SAMPLING PLAN

A sampling plan for each AQL value shall be selected from Table D-3 or D-4 as follows:

D9.1 Determination of Sample Size Code Letter. The sample size code letter shall be selected from Table A-2 in accordance with paragraph A7.1.

D9.2 Master Sampling Tables. The master sampling tables for plans based on variability known for a double specification limit are Tables D-3 and D-4. Table D-3 is used for normal and tightened inspection and Table D-4 for reduced inspection.

D9.3 Obtaining Sampling Plan. A sampling plan consists of a sample size and an associated maximum allowable percent defective(s). The sampling plan to be applied in inspection shall be obtained from Master Table D-3 or D-4.

D9.3.1 Sample Size. The sample size n is shown in the master tables corresponding to each sample size code letter and AQL.

D9.3.2 Maximum Allowable Percent Defective. The maximum allowable percent defective for sample estimates of percent defective for the lower, upper, or both specification limits combined, corresponding to the sample size mentioned in paragraph D9.3.1, is shown in the column of the master table corresponding to the applicable AQL value(s). If different AQL's are assigned to each specification limit, designate the maximum allowable percent defective by M_L for the lower limit, and by M_U for the upper limit. If one AQL is assigned to both limits combined, designate the maximum allowable percent defective by M. Table D-3 is entered from the top for normal inspection and from the bottom for tightened inspection. Sampling plans for reduced inspection are provided in Table D-4.

D10. DRAWING OF SAMPLES

Samples shall be selected in accordance with paragraph A7.2.

D11. LOT-BY-LOT ACCEPTABILITY PROCEDURES

D11.1 Acceptability Criterion. The degree of conformance of a quality characteristic with respect to a double specification limit shall be judged by the percent of nonconforming product. The percentage of nonconforming product is estimated by entering Table D-5 with the quality index.

D11.2 Computation of Quality Indices. The quality indices $Q_U = (U-\bar{X})v/\sigma$ and $Q_L = (\bar{X}-L)v/\sigma$ shall be computed, where

U is the upper specification limit,
L is the lower specification limit,
v is a factor provided in Tables D-3 and D-4,
$\bar{X}$ is the sample mean, and
σ is the known variability.

D11.3 Percent Defective in the Lot. The quality of a lot shall be expressed in terms of the lot percent defective. Its estimate will be designated by p_L, p_U, or p. The estimate p_U indicates conformance with respect to the upper specification limit, p_L with respect to the lower specification limit, and p for both specification limits combined. The estimates p_L and p_U shall be determined by entering Table D-5, respectively with Q_L and Q_U. The estimate p shall be determined by adding the corresponding estimated percent defectives p_L and p_U found in the table.

D12. ACCEPTABILITY CRITERION AND SUMMARY FOR OPERATION OF SAMPLING PLANS

D12.1 One AQL value for both Upper and Lower Specification Limit Combined.

D12.1.1 Acceptability Criterion.[4] Compare the estimated lot percent defective $p = p_U + p_L$ with the maximum allowable percent defective M. If p is equal to or less than M, the lot meets the acceptability criterion; if p is greater than M or if Q_U or Q_L or both are negative, then the lot does not meet the acceptability criterion.

D12.1.2 Summary of Operation of Sampling Plan. In cases where a single AQL value is established for the upper and lower specification limit combined for a single quality characteristic, the following steps summarize the procedures to be used:

(1) Determine the sample size code letter from Table A-2 by using the lot size and the inspection level.

(2) Select plan from Master Table D-3 or D-4. Obtain the sample size n, the factor v, and the maximum allowable percent defective M.

(3) Select at random the sample of n units from the lot; inspect and record the measurement of the quality characteristic on each unit of the sample.

(4) Compute the sample mean $\bar{X}$.

(5) Compute the quality indices $Q_U = (U-\bar{X})v/\sigma$ and $Q_L = (\bar{X}-L)v/\sigma$.

(6) Determine the estimated lot percent defective $p = p_U + p_L$ from Table D-5.

(7) If the estimated lot percent defective p is equal to or less than the maximum allowable percent defective M, the lot meets the acceptability criterion; if p is greater than M or if Q_U or Q_L or both are negative, then the lot does not meet the acceptability criterion.

D12.2 Different AQL Values for Upper and Lower Specification Limit.

D12.2.1 Acceptability Criteria.[5] Compare the estimated lot percent defectives p_L and p_U with the corresponding maximum allowable percent defectives M_L and M_U; also compare $p = p_L + p_U$ with the larger of M_L and M_U. If p_L is equal to or less than M_L, p_U is equal to or less than M_U, and p is equal to or less than the larger of M_L and M_U, the lot meets the acceptability criteria; otherwise, the lot does not meet the acceptability criteria. If either Q_L or Q_U or both are negative, then the lot does not meet the acceptability criteria.

D12.2.2 Summary of Operation of Sampling Plan. In cases where a different AQL value is established for the upper and lower specification limit for a single quality characteristic, the following steps summarize the procedures to be used:

(1) Determine the sample size code letter from Table A-2 by using the lot size and inspection level.

(2) Select the sampling plan from Master Table D-3 or D-4. Obtain the sample size n and the factor v, corresponding to the larger of the two AQL values, and also the maximum allowable percent defectives M_U and M_L, corresponding to the AQL values for the upper and lower specification limits, respectively.

(3) Select at random the sample of n units from the lot; inspect and record the measurement of the quality characteristic on each unit in the sample.

(4) Compute the sample mean $\bar{X}$.

(5) Compute the quality indices $Q_U = (U-\bar{X})v/\sigma$ and $Q_L = (\bar{X}-L)v/\sigma$.

(6) Determine the estimated lot percent defectives p_U and p_L, corresponding to the percent defectives above the upper and below the lower specification limits. Also determine the combined percent defective $p = p_U + p_L$.

(7) If all three of the following conditions:

(a) p_U is equal to or less than M_U,

(b) p_L is equal to or less than M_L,

(c) p is equal to or less than the larger of M_L and M_U,

are satisfied, the lot meets the acceptability criteria; otherwise, the lot does not meet the acceptability criteria. If either Q_L or Q_U or both are negative, then the lot does not meet the acceptability criteria.

[4] See Example D-3 for a complete example of this procedure.
[5] See Example D-4 for a complete example of this procedure.

EXAMPLE D-3

Example of Calculations

Double Specification Limit

Variability Known

One AQL Value for Both Upper and Lower Specification Limit Combined

Example The specified maximum and minimum yield points for certain steel castings are 67,000 psi and 58,000 psi, respectively. A lot of 500 items is submitted for inspection. Inspection Level IV, normal inspection, with AQL = 1.5% is to be used. The variability σ is known to be 3,000 psi. From Tables A-2 and D-3 it is seen that a sample of size 10 is required. Suppose the yield points of the sample specimens are:

62,500; 60,500; 68,000; 59,000; 65,500;
62,000; 61,000; 69,000; 58,000; 64,500;

and compliance with the acceptability criterion is to be determined.

Line	Information Needed	Value Obtained	Explanation
1	Sample Size: n	10	
2	Known Variability: σ	3,000	
3	Sum of Measurements: ΣX	630,000	
4	Sample Mean $\bar{X}$: $\Sigma X/n$	63,000	630,000/10
5	Factor: v	1.054	See Table D-3
6	Upper Specification Limit: U	67,000	
7	Lower Specification Limit: L	58,000	
8	Quality Index: $Q_U = (U-\bar{X})v/\sigma$	1.41	(67,000-63,000)1.054/3,000
9	Quality Index: $Q_L = (\bar{X}-L)v/\sigma$	1.76	(63,000-58,000)1.054/3,000
10	Est. of Lot Percent Def. Above U: p_U	7.93%	See Table D-5
11	Est. of Lot Percent Def. Below L: p_L	3.92%	See Table D-5
12	Total Est. Percent Def. in Lot: $p = p_U + p_L$	11.85%	7.93% + 3.92%
13	Max. Allowable Percent Def.: M	3.63%	See Table D-3
14	Acceptability Criterion: Compare $p = p_U + p_L$ with M	11.85% > 3.63%	See Para. D11.4

The lot does not meet the acceptability criterion, since $p = p_U + p_L$ is greater than M.

EXAMPLE D-4

Example of Calculations

Double Specification Limit

Variability Known

Different AQL Values for Upper and Lower Specification Limits

Example The specified maximum and minimum yield points for certain steel castings are 67,000 psi and 58,000 psi, respectively. A lot of 500 items is submitted for inspection. Inspection Level IV, normal inspection with AQL = 1% for the upper and AQL = 2.5% for the lower specification limit is to be used. The variability σ is known to be 3,000 psi. From Tables A-2 and D-3 it is seen that a sample of size 11 corresponding to the sample size code letter, I, and the AQL value of 2.5% is required. Suppose the yield points of the sample specimens are:

62,500; 60,500; 64,000; 59,000; 65,500;
62,000; 61,000; 60,631; 68,000; 62,000; 63,000

and compliance with the acceptability criteria is to be determined.

Line	Information Needed	Value Obtained	Explanation
1	Sample Size: n	11	
2	Known Variability: σ	3,000	
3	Sum of Measurements: ΣX	678,131	
4	Sample Mean $\bar{X}$: $\Sigma X/n$	61,648	678,131/11
5	Factor: v	1.049	See Table D-3
6	Upper Specification Limit: U	67,000	
7	Lower Specification Limit: L	58,000	
8	Quality Index: $Q_U = (U-\bar{X})v/\sigma$	1.87	(67,000-61,648)1.049/3,000
9	Quality Index: $Q_L = (\bar{X}-L)v/\sigma$	1.28	(61,648-58,000)1.049/3,000
10	Est. of Lot Percent Def. Above U: p_U	3.07%	See Table D-5
11	Est. of Lot Percent Def. Below L: p_L	10.03%	See Table D-5
12	Total Est. Percent Def. in Lot: $p = p_U + p_L$	13.10%	3.07% + 10.03%
13	Max. Allowable Percent Def. Above U: M_U	2.59%	See Table D-3
14	Max. Allowable Percent Def. Below L: M_L	5.60%	See Table D-3
15	Acceptability Criteria: (a) Compare p_U with M_U	3.07% > 2.59%	See Para. D12.2.2(7)(a)
	(b) Compare p_L with M_L	10.03% > 5.60%	See Para. D12.2.2(7)(b)
	(c) Compare p with M_L	13.10% > 5.60%	See Para. D12.2.2(7)(c)

The lot does not meet the acceptability criteria, since 15(a), (b) and (c) are not satisfied; i.e., $p_U > M_U$, $p_L > M_L$, and $p > M_L$.

TABLE D-3

Master Table for Normal and Tightened Inspection for Plans Based on Known Variability
(Double Specification Limit and Form 2—Single Specification Limit)

Sample size code letter	Acceptable Quality Levels (normal inspection)																				
	.04			.065			.10			.15			.25			.40			.65		
	n	M	v	n	M	v	n	M	v	n	M	v	n	M	v	n	M	v	n	M	v
B		↓			↓			↓			↓			↓			↓			↓	
C																					
D																			2	1.28	1.414
E													2	.310	1.414	2	.510	1.414	3	1.94	1.225
F										3	.369	1.225	3	.568	1.225	3	.959	1.225	4	1.88	1.155
G	3	.079	1.225	3	.114	1.225	4	.290	1.155	4	.399	1.155	4	.681	1.155	5	1.09	1.118	5	1.76	1.118
H	4	.111	1.115	4	.161	1.155	5	.296	1.118	5	.445	1.118	6	.721	1.095	6	1.14	1.095	7	1.75	1.080
I	5	.130	1.118	6	.230	1.095	6	.321	1.095	6	.478	1.095	7	.756	1.080	8	1.14	1.069	8	1.80	1.069
J	6	.145	1.095	6	.234	1.095	7	.343	1.080	7	.507	1.080	8	.791	1.069	9	1.18	1.061	10	1.79	1.054
K	7	.141	1.080	7	.226	1.080	8	.330	1.069	9	.469	1.061	9	.760	1.061	10	1.14	1.054	11	1.73	1.049
L	8	.153	1.069	8	.243	1.069	9	.351	1.061	10	.494	1.054	11	.768	1.049	12	1.15	1.045	13	1.74	1.041
M	10	.141	1.054	11	.217	1.049	11	.326	1.049	12	.461	1.045	13	.721	1.041	14	1.08	1.038	16	1.62	1.003
N	14	.138	1.038	15	.211	1.035	16	.308	1.033	17	.438	1.031	19	.673	1.027	21	1.00	1.025	23	1.51	1.023
O	19	.134	1.027	20	.207	1.026	22	.296	1.024	23	.423	1.023	25	.655	1.021	27	.980	1.019	30	1.47	1.017
P	27	.129	1.019	30	.193	1.017	31	.283	1.017	34	.397	1.015	37	.615	1.014	40	.921	1.013	44	1.39	1.012
Q	37	.130	1.014	40	.196	1.013	42	.285	1.012	45	.402	1.011	49	.620	1.010	54	.920	1.009	59	1.39	1.009
	.065			.10			.15			.25			.40			.65			1.00		
	Acceptable Quality Levels (tightened inspection)																				

All AQL and table values are in percent defective.

↓ Use first sampling plan below arrow, that is, both sample size as well as M value. When sample size equals or exceeds lot size, every item in the lot must be inspected.

TABLE D-3--Continued

Master Table for Normal and Tightened Inspection for Plans Based on Known Variability
(Double Specification Limit and Form 2--Single Specification Limit)

Sample size code letter	Acceptable Quality Levels (normal inspection)																				
	1.00			1.50			2.50			4.00			6.50			10.00			15.00		
	n	M	v	n	M	v	n	M	v	n	M	v	n	M	v	n	M	v	n	M	v
B		↓			↓			↓			↓			↓			↓			↓	
C	2	2.73	1.414	2	3.90	1.414	2	6.11	1.414	6	9.27	1.414	3	17.74	1.225	3	24.22	1.225	4	33.67	1.155
D	2	2.23	1.414	2	3.00	1.414	3	7.56	1.225	3	10.79	1.225	3	15.60	1.225	4	22.97	1.155	4	31.01	1.155
E	3	2.76	1.225	3	3.85	1.225	4	6.99	1.155	4	9.97	1.155	5	15.21	1.118	5	20.80	1.118	6	28.64	1.095
F	4	2.58	1.155	4	3.87	1.155	5	6.05	1.118	5	8.92	1.118	6	13.89	1.095	7	19.46	1.080	8	26.64	1.069
G	6	2.57	1.095	6	3.77	1.095	7	5.83	1.080	8	8.62	1.069	9	12.88	1.061	11	17.88	1.049	12	24.88	1.045
H	7	2.62	1.080	8	3.68	1.069	9	5.68	1.061	10	8.43	1.054	12	12.35	1.045	14	17.36	1.038	16	23.96	1.033
I	9	2.59	1.061	10	3.63	1.054	11	5.60	1.049	13	8.13	1.041	15	12.04	1.035	17	17.05	1.031	20	23.43	1.026
J	11	2.57	1.049	12	3.61	1.045	13	5.58	1.041	15	8.13	1.035	18	11.88	1.029	21	16.71	1.025	24	23.13	1.022
K	12	2.49	1.045	14	3.43	1.038	15	5.34	1.035	18	7.72	1.029	20	11.57	1.026	24	16.23	1.022	27	22.63	1.019
L	14	2.51	1.038	15	3.54	1.035	18	5.29	1.029	20	7.80	1.026	23	11.56	1.023	27	16.27	1.019	31	22.57	1.017
M	17	2.35	1.031	19	3.28	1.027	22	4.98	1.024	25	7.34	1.021	39	10.93	1.018	33	15.61	1.016	38	21.77	1.013
N	25	2.19	1.021	28	3.05	1.018	32	4.68	1.016	36	6.95	1.014	42	10.40	1.012	49	14.87	1.010	56	20.90	1.009
O	33	2.12	1.016	36	2.99	1.014	42	4.55	1.012	48	6.75	1.011	55	10.17	1.009	64	14.58	1.008	75	20.48	1.007
P	49	2.00	1.010	54	2.82	1.009	61	4.35	1.008	70	6.48	1.007	82	9.76	1.006	95	14.09	1.005	111	19.90	1.005
Q	65	2.00	1.008	71	2.82	1.007	81	4.34	1.006	93	6.46	1.005	109	9.73	1.005	127	14.02	1.004	147	19.84	1.003
	1.50			2.50			4.00			6.50			10.00			15.00					
	Acceptable Quality Levels (tightened inspection)																				

All AQL and table values are in percent defective.

↓ Use first sampling plan below arrow, that is, both sample size as well as M value. When sample size equals or exceeds lot size, every item in the lot must be inspected.

TABLE D-4

Master Table for Reduced Inspection for Plans Based on Known Variability
(Double Specification Limit and Form 2—Single Specification Limit)

Sample size code letter	Acceptable Quality Levels																				
	.04			.065			.10			.15			.25			.40			.65		
	n	M	v	n	M	v	n	M	v	n	M	v	n	M	v	n	M	v	n	M	v
B		↓			↓			↓			↓			↓			↓			↓	
C		↓			↓			↓			↓			↓			↓			↓	
D		↓			↓			↓			↓			↓			↓			↓	
E		↓			↓			↓			↓			↓			↓			↓	
F		↓			↓			↓			↓			↓			↓		2	2.73	1.414
G		↓			↓			↓			↓			↓		2	1.28	1.414	2	2.23	1.414
H		↓			↓			↓		2	.310	1.414	2	.510	1.414	3	1.94	1.225	3	2.76	1.225
I		↓			↓		3	.369	1.225	3	.568	1.225	3	.959	1.225	4	1.88	1.155	4	2.58	1.155
J		↓			↓		3	.369	1.225	3	.568	1.225	3	.959	1.225	4	1.88	1.155	4	2.58	1.155
K	3	.114	1.225	4	.290	1.155	4	.399	1.155	4	.681	1.155	5	1.09	1.118	5	1.76	1.118	6	2.57	1.095
L	4	.161	1.155	5	.296	1.118	5	.445	1.118	6	.721	1.095	6	1.14	1.095	7	1.75	1.080	7	2.62	1.080
M	4	.161	1.155	5	.296	1.118	5	.445	1.118	6	.721	1.095	6	1.14	1.095	7	1.75	1.080	7	2.62	1.080
N	6	.230	1.095	6	.321	1.095	6	.478	1.095	7	.756	1.080	8	1.14	1.069	8	1.80	1.069	9	2.59	1.061
O	6	.234	1.095	7	.343	1.080	7	.507	1.080	8	.791	1.069	9	1.18	1.061	10	1.79	1.054	11	2.57	1.049
P	11	.217	1.049	11	.326	1.049	12	.461	1.045	13	.721	1.041	14	1.08	1.038	16	1.62	1.033	17	2.35	1.031
Q	15	.211	1.035	16	.308	1.033	17	.438	1.031	19	.673	1.027	21	1.00	1.025	23	1.51	1.023	25	2.19	1.021

All AQL and table values are in percent defective.

↓ Use first sampling plan below arrow, that is, both sample size as well as M value. When sample size equals or exceeds lot size, every item in the lot must be inspected.

TABLE D-4--Continued

Master Table for Reduced Inspection for Plans Based on Known Variability
(Double Specification Limit and Form 2--Single Specification Limit)

Sample size code letter	Acceptable Quality Levels																	
	1.00			1.50			2.50			4.0			6.5			10.00		
	n	M	v	n	M	v	n	M	v	n	M	v	n	M	v	n	M	v
B		↓			↓			↓			↓			↓			↓	
C																		
D																		
E																		
F	2	3.90	1.414	2	6.11	1.414	2	9.27	1.414	3	17.74	1.225	3	24.22	1.225	4	33.67	1.225
G	2	3.00	1.414	3	7.56	1.225	3	10.79	1.225	3	15.60	1.225	4	22.97	1.155	4	31.01	1.155
H	3	3.85	1.225	4	6.99	1.155	4	9.97	1.155	5	15.21	1.118	5	20.80	1.118	6	28.64	1.095
I	4	3.87	1.155	5	6.05	1.118	5	8.92	1.118	6	13.89	1.095	7	19.46	1.080	8	26.64	1.069
J	4	3.87	1.155	5	6.05	1.118	5	8.92	1.118	6	13.89	1.095	7	19.46	1.080	8	26.64	1.069
K	6	3.77	1.095	7	5.83	1.080	8	8.62	1.069	9	12.88	1.061	11	17.88	1.049	12	24.88	1.045
L	8	3.68	1.069	9	5.68	1.061	10	8.43	1.054	12	12.35	1.045	14	17.36	1.038	16	23.96	1.033
M	8	3.68	1.069	9	5.68	1.061	10	8.43	1.054	12	12.35	1.045	14	17.36	1.038	16	23.96	1.033
N	10	3.63	1.054	11	5.60	1.049	13	8.13	1.041	15	12.04	1.035	17	17.05	1.031	20	23.43	1.026
O	12	3.61	1.045	13	5.58	1.041	15	8.13	1.035	18	11.88	1.029	21	16.71	1.025	24	23.13	1.022
P	19	3.28	1.027	22	4.98	1.024	25	7.34	1.021	29	10.93	1.018	33	15.61	1.016	38	21.77	1.013
Q	28	3.05	1.018	32	4.68	1.016	36	6.95	1.014	42	10.40	1.012	49	14.87	1.010	56	20.90	1.009

All AQL and table values are in percent defective.

↓ Use first sampling plan below arrow, that is, both sample size as well as M value. When sample size equals or exceeds lot size, every item in the lot must be inspected.

TABLE D-5

Table for Estimating the Lot Percentage Defective for Plans Based on Known Variability[1]

Q_U or Q_L		Q_U or Q_L		Q_U or Q_L		Q_U or Q_L		Q_U or Q_L		Q_U or Q_L		Q_U or Q_L		Q_U or Q_L		Q_U or Q_L		Q_U or Q_L		Q_U or Q_L		Q_U or Q_L		Q_U or Q_L		Q_U or Q_L		Q_U or Q_L		Q_U or Q_L	
.00	50.000																														
.01	49.601	.26	39.743	.51	30.503	.76	22.363	1.01	15.625	1.26	10.383	1.51	06.552	1.76	03.920	2.01	02.222	2.26	01.191	2.51	00.604	2.76	00.289	3.01	00.131	3.26	00.056	3.51	00.022	3.76	00.008
.02	49.202	.27	39.358	.52	30.153	.77	22.065	1.02	15.386	1.27	10.204	1.52	06.426	1.77	03.836	2.02	02.169	2.27	01.160	2.52	00.587	2.77	00.280	3.02	00.126	3.27	00.054	3.52	00.022	3.77	00.008
.03	48.803	.28	38.974	.53	29.806	.78	21.770	1.03	15.150	1.28	10.027	1.53	06.301	1.78	03.754	2.03	02.118	2.28	01.130	2.53	00.570	2.78	00.272	3.03	00.122	3.28	00.052	3.53	00.021	3.78	00.008
.04	48.405	.29	38.591	.54	29.460	.79	21.476	1.04	14.917	1.29	09.853	1.54	06.178	1.79	03.673	2.04	02.068	2.29	01.101	2.54	00.554	2.79	00.264	3.04	00.118	3.29	00.050	3.54	00.020	3.79	00.008
.05	48.006	.30	38.209	.55	29.116	.80	21.186	1.05	14.686	1.30	09.680	1.55	06.057	1.80	03.593	2.05	02.018	2.30	01.072	2.55	00.539	2.80	00.256	3.05	00.114	3.30	00.048	3.55	00.019	3.80	00.007
.06	47.608	.31	37.828	.56	28.774	.81	20.897	1.06	14.457	1.31	09.510	1.56	05.938	1.81	03.515	2.06	01.970	2.31	01.044	2.56	00.523	2.81	00.248	3.06	00.111	3.31	00.047	3.56	00.019	3.81	00.007
.07	47.210	.32	37.448	.57	28.434	.82	20.611	1.07	14.231	1.32	09.342	1.57	05.821	1.82	03.438	2.07	01.923	2.32	01.017	2.57	00.508	2.82	00.240	3.07	00.107	3.32	00.045	3.57	00.018	3.82	00.007
.08	46.812	.33	37.070	.58	28.096	.83	20.327	1.08	14.007	1.33	09.176	1.58	05.705	1.83	03.362	2.08	01.876	2.33	00.990	2.58	00.494	2.83	00.233	3.08	00.103	3.33	00.043	3.58	00.017	3.83	00.006
.09	46.414	.34	36.693	.59	27.760	.84	20.045	1.09	13.786	1.34	09.012	1.59	05.592	1.84	03.288	2.09	01.831	2.34	00.964	2.59	00.480	2.84	00.226	3.09	00.100	3.34	00.042	3.59	00.017	3.84	00.006
.10	46.017	.35	36.317	.60	27.425	.85	19.766	1.10	13.567	1.35	08.851	1.60	05.480	1.85	03.216	2.10	01.786	2.35	00.939	2.60	00.466	2.85	00.219	3.10	00.097	3.35	00.040	3.60	00.016	3.85	00.006
.11	45.620	.36	35.942	.61	27.093	.86	19.489	1.11	13.350	1.36	08.691	1.61	05.370	1.86	03.144	2.11	01.743	2.36	00.914	2.61	00.453	2.86	00.212	3.11	00.094	3.36	00.039	3.61	00.015	3.86	00.006
.12	45.224	.37	35.569	.62	26.763	.87	19.215	1.12	13.136	1.37	08.534	1.62	05.262	1.87	03.074	2.12	01.700	2.37	00.889	2.62	00.440	2.87	00.205	3.12	00.090	3.37	00.038	3.62	00.015	3.87	00.005
.13	44.828	.38	35.197	.63	26.435	.88	18.943	1.13	12.924	1.38	08.379	1.63	05.155	1.88	03.005	2.13	01.659	2.38	00.866	2.63	00.427	2.88	00.199	3.13	00.087	3.38	00.036	3.63	00.014	3.88	00.005
.14	44.433	.39	34.827	.64	26.109	.89	18.673	1.14	12.714	1.39	08.226	1.64	05.050	1.89	02.938	2.14	01.618	2.39	00.842	2.64	00.415	2.89	00.193	3.14	00.084	3.39	00.035	3.64	00.014	3.89	00.005
.15	44.038	.40	34.458	.65	25.785	.90	18.406	1.15	12.507	1.40	08.076	1.65	04.947	1.90	02.872	2.15	01.578	2.40	00.820	2.65	00.402	2.90	00.187	3.15	00.082	3.40	00.034	3.65	00.013	3.90	00.005
.16	43.644	.41	34.090	.66	25.463	.91	18.141	1.16	12.302	1.41	07.927	1.66	04.846	1.91	02.807	2.16	01.539	2.41	00.798	2.66	00.391	2.91	00.181	3.16	00.079	3.41	00.032	3.66	00.013	3.91	00.005
.17	43.251	.42	33.724	.67	25.143	.92	17.879	1.17	12.100	1.42	07.780	1.67	04.746	1.92	02.743	2.17	01.500	2.42	00.776	2.67	00.379	2.92	00.175	3.17	00.076	3.42	00.031	3.67	00.012	3.92	00.004
.18	42.858	.43	33.360	.68	24.825	.93	17.619	1.18	11.900	1.43	07.636	1.68	04.648	1.93	02.680	2.18	01.463	2.43	00.755	2.68	00.368	2.93	00.169	3.18	00.074	3.43	00.030	3.68	00.012	3.93	00.004
.19	42.465	.44	32.997	.69	24.510	.94	17.361	1.19	11.702	1.44	07.493	1.69	04.551	1.94	02.619	2.19	01.426	2.44	00.734	2.69	00.357	2.94	00.164	3.19	00.071	3.44	00.029	3.69	00.011	3.94	00.004
.20	42.074	.45	32.636	.70	24.196	.95	17.106	1.20	11.507	1.45	07.353	1.70	04.457	1.95	02.559	2.20	01.390	2.45	00.714	2.70	00.347	2.95	00.159	3.20	00.069	3.45	00.028	3.70	00.011	3.95	00.004
.21	41.683	.46	32.276	.71	23.885	.96	16,853	1.21	11.314	1.46	07.214	1.71	04.363	1.96	02.500	2.21	01.355	2.46	00.695	2.71	00.336	2.96	00.154	3.21	00.066	3.46	00.027	3.71	00.010	3.96	00.004
.22	41.294	.47	31.918	.72	23.576	.97	16.602	1.22	11.123	1.47	04.078	1.72	04.272	1.97	02.442	2.22	01.321	2.47	00.676	2.72	00.326	2.97	00.149	3.22	00.064	3.47	00.026	3.72	00.010	3.97	00.004
.23	40.905	.48	31.561	.73	23.270	.98	16.354	1.23	10.935	1.48	06.944	1.73	04.182	1.98	02.385	2.23	01.287	2.48	00.657	2.73	00.317	2.98	00.144	3.23	00.062	3.48	00.025	3.73	00.010	3.98	00.003
.24	40.517	.49	31.207	.74	22.965	.99	16.109	1.24	10.749	1.49	06.811	1.74	04.093	1.99	02.330	2.24	01.255	2.49	00.639	2.74	00.307	2.99	00.139	3.24	00.060	3.49	00.024	3.74	00.009	3.99	00.003
.25	40.129	.50	30.854	.75	22.663	1.00	15.866	1.25	10.565	1.50	06.681	1.75	04.006	2.00	02.275	2.25	01.222	2.50	00.621	2.75	00.298	3.00	00.135	3.25	00.058	3.50	00.023	3.75	00.009	4.00	00.003

[1]Values tabulated are read in percent.

Part III

ESTIMATION OF PROCESS AVERAGE AND CRITERIA FOR REDUCED AND TIGHTENED INSPECTION

D13. ESTIMATION OF PROCESS AVERAGE

The average percent defective, based upon a group of lots submitted for original inspection, is called the process average. Original inspection is the first inspection of a particular quantity of product submitted for acceptability as distinguished from the inspection of product which has been resubmitted after prior rejection. The process average shall be estimated from the results of inspection of samples drawn from a specified number of preceding lots for the purpose of determining severity of inspection during the course of a contract in accordance with paragraph D14.3. Any lot shall be included only once in estimating the process average. The estimate of the process average is designated by $\bar{p}_U$ when computed with respect to an upper specification limit, by $\bar{p}_L$ when computed with respect to a lower specification limit, and by p when computed with respect to a double specification limit.

D13.1 Abnormal Results. The results of inspection of product manufactured under conditions not typical of usual production shall be excluded from the estimated process average.

D13.2 Computation of the Estimated Process Average. The estimated process average is the arithmetic mean of the estimated lot percent defective computed from the sampling inspection results of the preceding ten (10) lots or as may be otherwise designated. In order to estimate the lot percent defective, the quality indices Q_U and/or Q_L shall be computed for each lot. These are: $Q_U = (U-\bar{X})v/\sigma$ and $Q_L = (\bar{X}-L)v/\sigma$. (See paragraph D11.2.)

D13.2.1 Single Specification Limit.[6] The estimated lot percent defective shall be determined from Table D-5 for the plans based on known variability. The quality index Q_U shall be used for the case of an upper specification limit or Q_L for the case of a lower specification limit. Table D-5 is entered with Q_U or Q_L and the corresponding estimated lot percent defective p_U or p_L, respectively, is read from the table. The estimated process average $\bar{p}_U$ is the arithmetic mean of the individual estimated lot percent defectives p_U's. Similarly, the estimated process average $\bar{p}_L$ is the arithmetic mean of the individual estimated lot percent defectives p_L's.

D13.2.2 Double Specification Limit. The estimated lot percent defective shall be determined from Table D-5 for the plans based on variability known. The quality indices Q_U and Q_L shall be computed. Table D-5 is entered separately with Q_U and Q_L and the corresponding p_U and p_L are read from the table. The estimated lot percent defective is $p = p_U + p_L$. The estimated process average $\bar{p}$ is the arithmetic mean of the individual estimated lot percent defectives p's.

D13.2.3 Special Case. If the quality index Q_U or Q_L is a negative number, then Table D-5 is entered by disregarding the negative sign. However, in this case the estimated lot percent defective above the upper limit or below the lower limit is obtained by subtracting the percentage found in the table from 100%.[7]

D14. NORMAL, TIGHTENED, AND REDUCED INSPECTION

This Standard establishes sampling plans for normal, tightened, and reduced inspection.

D14.1 At Start of Inspection. Normal inspection shall be used at the start of inspection unless otherwise designated.

D14.2 During Inspection. During the course of inspection, normal inspection shall be used when inspection conditions are such that tightened or reduced inspection is not required in accordance with paragraphs D14.3 and D14.4.

D14.3 Tightened Inspection. Tightened inspection shall be instituted when the estimated process average computed from the

[6] When Form 1—Single Specification Limit is used for the acceptability criterion, the estimate of lot percent defective p_U or p_L is not obtained; in order to estimate the process average, it is necessary to complete paragraphs D6.2 and D6.3 of Form 2.

[7] For example, if $Q_U = -.50$ and $Q_L = 1.60$, then $p_U = 100\% - 30.854\% = 69.146\%$, $p_L = 5.48\%$ and $p = 69.146\% + 5.48\% = 74.626\%$.

preceding ten (10) lots (or such other number of lots designated) in accordance with paragraph D13.2 is greater than the AQL, and when more than a certain number T of these lots have estimates of the percent defective exceeding the AQL. The T-values are given in Table D-6 when the process average is computed from 5, 10, or 15 lots.[8] Normal inspection shall be reinstated if the estimated process average of lots under tightened inspection is equal to or less than the AQL.

D14.4 Reduced Inspection. Reduced inspection may be instituted provided that all of the following conditions are satisfied:

Condition A. The preceding ten (10) lots (or such other number of lots designated) have been under normal inspection and none has been rejected.

Condition B. The estimated percent defective for each of these preceding lots is less than the applicable lower limit shown in Table D-7.

Condition C. Production is at a steady rate.

Normal inspection shall be reinstated if any one of the following conditions occurs under reduced inspection:

Condition D. A lot is rejected.

Condition E. The estimated process average is greater than the AQL.

Condition F. Production becomes irregular or delayed.

Condition G. Other conditions as may warrant that normal inspection should be reinstated.

D14.5 Sampling Plans for Tightened or Reduced Inspection. Sampling plans for tightened and reduced inspection are provided in Section D, Parts I and II.

[8] If the sample size code letter is not the same for all samples used, the entry in Table D-6 is determined by the sample size code letter corresponding to the smallect sample size used in any of the lots included in the estimation of the process average.

TABLE D-6

Variability Known

Values of T for Tightened Inspection

Sample size code letter	.04	.065	.10	.15	.25	.40	.65	1.0	1.5	2.5	4.0	6.5	10.0	15.0	Number of Lots
B	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
C	*	*	*	*	*	*	*	3 5 6	3 5 6	3 5 7	3 6 7	4 7 9	4 7 9	4 7 10	5 10 15
D	*	*	*	*	*	*	3 4 6	3 5 6	3 5 6	4 6 8	4 6 9	4 7 9	4 7 10	4 7 10	5 10 15
E	*	*	*	*	2 4 5	3 4 6	3 5 7	3 6 7	3 6 8	4 6 9	4 7 9	4 7 10	4 7 10	4 8 11	5 10 15
F	*	*	*	3 5 6	3 5 7	3 5 7	4 6 8	4 6 8	4 6 8	4 7 9	4 7 9	4 7 10	4 7 10	4 8 11	5 10 15
G	3 4 6	3 4 6	3 5 7	3 5 7	3 6 7	4 6 8	4 6 8	4 7 9	4 7 9	4 7 10	4 7 10	4 7 10	4 8 11	4 8 11	5 10 15
H	3 5 6	3 5 7	3 6 7	3 6 8	4 6 8	4 6 9	4 7 9	4 7 9	4 7 10	4 7 10	4 7 10	4 8 11	4 8 11	4 8 11	5 10 15
I	3 5 7	4 6 8	4 6 8	4 6 8	4 6 9	4 7 9	4 7 9	4 7 9	4 7 10	4 7 10	4 7 10	4 8 11	4 8 11	4 8 11	5 10 15
J	3 6 8	4 6 8	4 6 8	4 6 8	4 6 9	4 7 9	4 7 9	4 7 10	4 7 10	4 7 10	4 8 11	4 8 11	4 8 11	4 8 11	5 10 15
K	4 6 8	4 6 8	4 6 9	4 6 9	4 7 9	4 7 9	4 7 10	4 7 10	4 7 10	4 7 10	4 8 11	4 8 11	4 8 11	4 8 11	5 10 15
L	4 6 8	4 6 9	4 6 9	4 7 9	4 7 9	4 7 10	4 7 10	4 7 10	4 7 10	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	5 10 15
M	4 6 9	4 7 9	4 7 9	4 7 9	4 7 10	4 7 10	4 7 10	4 7 10	4 7 10	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	5 10 15
N	4 7 9	4 7 9	4 7 10	4 7 10	4 7 10	4 7 10	4 7 10	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	5 10 15
O	4 7 10	4 7 10	4 7 10	4 7 10	4 7 10	4 7 10	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	4 8 11	5 10 15

Acceptable Quality Levels (in percent defective)

*There are no sampling plans provided in this Standard for these code letters and AQL values.

TABLE D-6—Continued

Values of T for Tightened Inspection

Sample size code letter	Acceptable Quality Levels (in percent defective) .04	.065	.10	.15	.25	.40	.65	1.0	1.5	2.5	4.0	6.5	10.0	15.0	Number of Lots
P	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5
	7	7	7	7	8	8	8	8	8	8	8	8	8	8	10
	10	10	10	10	11	11	11	11	11	11	11	11	11	11	15
Q	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5
	7	7	8	8	8	8	8	8	8	8	8	8	8	8	10
	10	10	11	11	11	11	11	11	11	11	11	11	11	11	15

The top figure in each block refers to the preceding 5 lots, the middle figure to the preceding 10 lots and the bottom figure to the preceding 15 lots.

Tightened inspection is required when the number of lots with estimates of percent defective above the AQL from the preceding 5, 10, or 15 lots is greater than the given value of T in the table, and the process average from these lots exceeds the AQL.

All estimates of the lot percent defective are obtained from Table D-5.

Variability Known

TABLE D-7

Limits of Estimated Lot Percent Defective for Reduced Inspection

Sample size code letter	Acceptable Quality Levels														Number of Lots
	.04	.065	.10	.15	.25	.40	.65	1.0	1.5	2.5	4.0	6.5	10.0	15.0	
B	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
C	*	*	*	*	*	*	*	.011	.027	.077	.205	1.645	3.226	7.714	5
								.109	.222	.542	1.217	4.496	7.912	14.291	10
								.209	.558	1.253	2.592	6.50	10.00	15.00	15
D	*	*	*	*	*	*	.005	.011	.027	.369	.769	1.645	4.386	7.714	5
							.050	.109	.222	1.248	2.354	4.496	8.845	14.291	10
							.144	.290	.558	2.145	3.850	6.50	10.00	15.00	15
E	*	*	*	*	.001	.002	.045	.088	.166	.637	1.225	2.937	5.154	9.479	5
					.009	.021	.197	.357	.622	1.643	2.924	5.697	9.330	15.00	10
					.029	.064	.384	.669	1.124	2.50	4.00	6.50	10.00	▲	15
F	*	*	*	.005	.010	.021	.098	.178	.313	.846	1.560	3.325	6.114	10.436	5
				.025	.052	.100	.309	.528	.874	1.880	3.250	5.958	9.806	15.00	10
				.056	.110	.204	.522	.867	1.394	2.50	4.00	6.50	10.00	▲	15
G	.001	.001	.007	.013	.026	.078	.147	.322	.533	1.136	2.166	4.045	7.093	11.478	5
	.004	.008	.029	.049	.093	.217	.385	.718	1.139	2.141	3.698	6.342	10.00	15.00	10
	.010	.018	.055	.090	.167	.347	.602	1.00	1.50	2.50	4.00	6.50	▲	▲	15
H	.002	.004	.013	.022	.057	.103	.223	.375	.677	1.326	2.403	4.453	7.502	12.054	5
	.009	.017	.041	.067	.147	.252	.478	.773	1.270	2.277	3.831	6.50	10.00	15.00	10
	.018	.033	.071	.114	.227	.382	.65	1.00	1.50	2.50	4.00	▲	▲	▲	15
I	.004	.011	.018	.030	.070	.142	.252	.457	.778	1.461	2.643	4.719	7.786	12.427	5
	.014	.031	.051	.081	.164	.298	.508	.847	1.346	2.359	3.942	6.50	10.00	15.00	10
	.025	.051	.082	.129	.244	.40	.65	1.00	1.50	2.50	4.00	▲	▲	▲	15
J	.006	.011	.023	.038	.082	.158	.298	.516	.853	1.562	2.758	4.909	8.055	12.693	5
	.018	.031	.058	.092	.177	.313	.549	.892	1.394	2.412	3.987	6.50	10.00	15.00	10
	.030	.051	.090	.140	.25	.40	.65	1.00	1.50	2.50	4.00	▲	▲	▲	15
K	.008	.014	.028	.051	.091	.171	.317	.540	.910	1.641	2.891	5.009	8.205	12.848	5
	.021	.036	.064	.108	.188	.326	.564	.908	1.427	2.449	4.00	6.50	10.00	15.00	10
	.033	.056	.096	.15	.25	.40	.65	1.00	1.50	2.50	▲	▲	▲	▲	15

*There are no sampling plans provided in this Standard for these code letters and AQL values.

TABLE D-7--Continued

Variability Known

Limits of Estimated Lot Percent Defective for Reduced Inspection

Sample size code letter	Acceptable Quality Levels														Number of Lots
	.04	.065	.10	.15	.25	.40	.65	1.0	1.5	2.5	4.0	6.5	10.0	15.0	
L	.009 .023 .036	.017 .040 .060	.032 .069 .10	.056 .113 .15	.107 .203 .25	.193 .344 .40	.348 .586 .65	.581 .934 1.00	.934 1.440 1.50	1.732 2.486 2.50	2.960 4.00 ▲	5.131 6.50 ▲	8.328 10.00 ▲	13.017 15.00 ▲	5 10 15
M	.012 .027 .039	.023 .048 .065	.038 .076 .10	.064 .121 .15	.120 .214 .25	.211 .357 .40	.383 .608 .65	.627 .959 1.00	1.010 1.475 1.50	1.821 2.50 ▲	3.093 4.00 ▲	5.310 6.50 ▲	8.516 10.00 ▲	13.238 15.00 ▲	5 10 15
N	.017 .032 .04	.030 .054 .065	.049 .086 .10	.080 .134 .15	.146 .232 .25	.251 .382 .40	.435 .635 .65	.705 .994 1.00	1.113 1.50 ▲	1.959 2.50 ▲	3.272 4.00 ▲	5.546 6.50 ▲	8.822 10.00 ▲	13.588 15.00 ▲	5 10 15
O	.020 .035 .04	.035 .058 .065	.058 .092 .10	.091 .141 .15	.161 .241 .25	.272 .392 .40	.467 .648 .65	.750 1.00 ▲	1.168 1.50 ▲	2.041 2.50 ▲	3.386 4.00 ▲	5.685 6.50 ▲	8.990 10.00 ▲	13.801 15.00 ▲	5 10 15
P	.024 .037 .04	.041 .062 .065	.066 .087 .10	.103 .147 .15	.180 .249 .25	.299 .40 ▲	.505 .65 ▲	.803 1.00 ▲	1.239 1.50 ▲	2.132 2.50 ▲	3.509 4.00 ▲	5.852 6.50 ▲	9.192 10.00 ▲	14.034 15.00 ▲	5 10 15
Q	.027 .039 .04	.045 .064 .065	.071 .099 .10	.110 .15 ▲	.191 .25 ▲	.316 .40 ▲	.528 .65 ▲	.834 1.00 ▲	1.278 1.50 ▲	2.188 2.50 ▲	3.583 4.00 ▲	5.949 6.50 ▲	9.312 10.00 ▲	14.173 15.00 ▲	5 10 15

All AQL and table values are in percent defective.

▲Use the first figure in direction of arrow and corresponding number of lots. In each block the top figure refers to the preceding 5 lots, the middle figure to the preceding 10 lots, and the bottom figure to the preceding 15 lots.

Reduced inspection may be instituted when every estimated lot percent defective from the preceding 5, 10, or 15 lots is below the figure given in the table. In addition, all other conditions for reduced inspection, in Part III of Section D, must be satisfied.

All estimates of the lot percent defective are obtained from Table D-5.

APPENDIX D

Definitions

Symbol	Read	Definitions
n		Sample size for a single lot.
$\bar{X}$	X bar	Sample mean. Arithmetic mean of sample measurements from a single lot.
σ	Sigma	Known variability. The predetermined variability of the quality characteristic which will be used with the variability known acceptability plans.
U		Upper specification limit.
L		Lower specification limit.
k		The acceptability constant given in Tables D-1 and D-2.
v		A factor used in determining the quality indices when using the known variability acceptability plan. The v values are given in Tables D-3 and D-4.
Q_U	Q sub U	Quality Index for use with Table D-5.
Q_L	Q sub L	Quality Index for use with Table D-5.
p_U	p sub U	Sample estimate of the lot percent defective above U from Table D-5.
p_L	p sub L	Sample estimate of the lot percent defective below L from Table D-5.
p		Total sample estimate of the lot percent defective $p = p_U + p_L$.
M		Maximum allowable percent defective for sample estimates given in Tables D-3 and D-4.
M_U	M sub U	Maximum allowable percent defective above U given in Tables D-3 and D-4. (For use when different AQL values for U and L are specified.)
M_L	M sub L	Maximum allowable percent defective below L given in Tables D-3 and D-4. (For use when different AQL values for U and L are specified.)
$\bar{p}$	p bar	Sample estimate of the process percent defective, i. e., the estimated process average.
$\bar{p}_U$	p bar sub U	The estimated process average for an upper specification limit.
$\bar{p}_L$	p bar sub L	The estimated process average for a lower specification limit.
T		The maximum number of estimated process averages which may exceed the AQL given in Table D-6. (For use in determining application of tightened inspection.)
$<$	Less than	Less than.
$>$	Greater than	Greater than.
Σ	Sum of	Sum of.

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